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WATER IN THE DESERT[1]

GEORGE B. CRESSEY
Syracuse University

EXACTLY a year ago I was traveling across one of the driest deserts of Iran. On the very day when many of you were listening to Professor Carl Sauer deliver his presidential address in Montreal I discovered, by chance, a cartoon from an old American magazine. This showed two camels standing in the midst of an equally desolate waste. Their conversation forms a fitting introduction to my own address on "Water in the Desert." One was saying to the other: "I don't care what people think, I'm thirsty."

The files of the *Annals* are full of presidential addresses which discuss the philosophy of geography. These have properly formed the basis for discussion in countless graduate seminars. I am sure that few students will turn to this year's paper for I have no brilliant ideas or profound advice to offer. In place of theory I will turn to practice, and perhaps therein is my chief advice: It is high time that geographers *do* something about the world rather than merely *describing* what anyone can see.

LAND AND WATER

Five years ago, in Washington, I surveyed the problem of "Land for 2.4 Billion Neighbors."[2] Already that figure has risen to 2.7. It is obvious that the world needs more food, but it is not the function of geographers to tell *how* it is to be produced; rather, we are concerned with *where* it may be grown. Not much more good land remains unused anywhere. It has been my exceptional fortune to have seen a little of about 65 countries the world around. Nowhere can one find virgin prairies similar to those which our ancestors plowed in the Mississippi Valley, or empty forest lands such as once surrounded Cincinnati.

All of the presently unused lands have something the matter with them. In words which some of you have heard me use before, they are either too mountainous or too hilly, too cold or too hot, too dry or too wet, too infertile, or too something or other to be very attractive as a home for large numbers of people.

If the exploding population of this planet is to feed itself, it seems likely that the largest increase in food may be secured through more efficient utilization of the presently used better land, rather than by venturing too far into the marginal areas (Moscow papers please copy).

Within our lifetime we have seen the end of individual pioneering in the humid lands. If we are to look for new areas to be cultivated, shall we turn to the cold, the wet, or the dry frontiers? And if there is promise in the arid lands, does this lie in additional acreage through dry farming, in new water for the desert, or in a more efficient use of the presently irrigated land? Whereas my earlier study was concerned with *land*, this paper is an examination of *water*.[3]

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[1] Presidential address given by the Honorary President of the Association of American Geographers at its 53rd Annual Meeting, Cincinnati, Ohio, April 3, 1957.

[2] George B. Cressey, "Land for 2.4 Billion Neighbors," *Economic Geography*, Vol. 29 (1953), pp. 1–9.

[3] See Gilbert White, ed., *The Future of Arid Lands* (Washington, 1956); the *Proceedings* of the United Nations Scientific Conference on the Conservation and Utilization of Resources (New York, 1951), Volume IV, *Water Resources*; and the various reports of the UNESCO Arid Zone Commission.

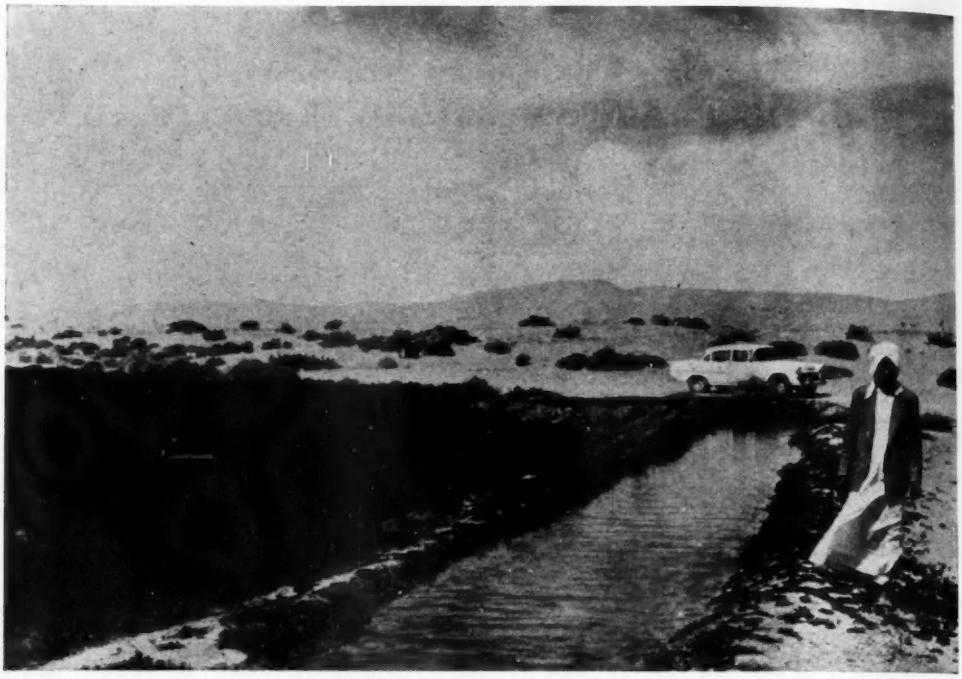

FIG. 1. Water in the Desert. This alfalfa field near Al Kharj in central Arabia is a reminder of the way in which irrigation canals may transform an arid waste. (*G. B. C.*)

Water is our most neglected asset, more valuable than any of the metals and perhaps even more critical than soil. Too much or too little creates problems, especially in dry lands. For the most part water is a renewable resource, but in many areas we are drawing upon reserves which required millenia to accumulate. When we pump deep-seated supplies we may be mining connate water which will never be replenished.

The Secretary of the Interior has recently reported to Congress that the United States is now using 250 billion gallons daily. This is six times the figure in 1900, and it is estimated that by 1980 the requirements will double.

Even in supposedly humid lands we are coming to use supplementary irrigation, as in western New York state where the Barge Canal may be more valuable as a source of irrigation water from Lake Erie than for commerce. To put it another way, in order to grow one ton of food on half an acre will require something like 4,000 tons of water.

If water is the key to the use of additional land, it is probably better to have too little rather than too much. Too much rain, as in the humid tropics, creates problems of disposal which may be more baffling than the problem of supply in the dry lands. If we are someday to modify the rainfall, there is more likelihood of inducing precipitation in dry lands than of preventing it in overly wet areas.

DESERT CRITERIA

There are many ways of defining a desert. Drought and scanty vegetation are obvious. From the standpoint of climatology, arid lands are generally areas where potential evapotranspiration exceeds precipitation. A special category of very dry deserts might be set up for areas which have experienced twelve consecutive months without rain.

To a hydrologist, deserts are areas where topographic depressions fail to be filled to overflowing so that drainage is centripetal, or

FIG. 2. Drought in the Desert. Without water, vegetation dies and animals perish, as in this scene near Riyadh in Saudi Arabia. (*G. B. C.*)

where there are no permanent rivers, or where withering streams fail to reach the sea.

Geologically speaking, dry lands have a characteristic morphology, though even in the driest areas the land forms show evidence of erosion by running water.

To a soil scientist, aridity is measured by the concentration of unleached salts.

The ecologist recognizes deserts and steppes by the association of xerophytic vegetation and by the wide spacing of individual plants, but it may be well to add that no place on earth, outside the polar ice caps, is completely lifeless. This botanical concept recognizes that there is insufficient water for the normal needs of vegetation. This may even occur with heavy rainfall if the soil is very porous. Thus the "Sand Sea" on the top of Tengger Volcano in Java is a desert in the midst of a rain forest.

In agricultural terms, arid lands are those where crops cannot be grown without irrigation, while in semiarid lands grazing is usually possible but crops can be raised only by special techniques of dry farming.

What are the geographic criteria for a desert? If we are to regard man as the most important item in geography, that is to say if geography is at least 51 percent a social science, then land *use* is of major significance. To a geographer, arid lands represent a complex of interactions between many factors: climate, ground water, land forms, soils, vegetation, and man's abuse of the land.

It is well to stress the fact that deserts are not purely environmental situations. Many present-day deserts owe some of their desolate appearance to human factors. This includes the lack of vegetation, the contour of the land, and perhaps even the concentration of rainfall and runoff. When a visitor calls at a Bedouin tent and is entertained with coffee, it may require four dozen desert shrubs for the small fire. Thus the area for miles around a nomad encampment becomes denuded, and any original vegetation may be thoroughly erased.

It is also important to emphasize that statistics may be of little value in defining a desert. Every year is exceptional. The climate

FIG. 3. Oases are islands in the desert, encircled by aridity and made possible by local supplies of water. This grove of date palms is in Saudi Arabia. (*Courtesy Arabian American Oil Company.*)

of dry lands is characterized as much by variability as by low precipitation. The term "semiarid" does not mean 15 inches per year, but rather that half the years are dry and half are wet. Whereas in humid stations the extreme range between wet and dry years may have a ratio of one to three or four, arid stations may have a range of one to ten or twenty. Annual averages of 5 inches should not be assumed to involve the same fluctuations as in humid lands. Baghdad and Dahran have each received almost their annual average in a day. Instead of listing a station as having 5 inches, we should describe it as receiving 50 inches in a decade. Even this may be misleading for there is no assurance of 500 inches every century.

Without waiting for a firm definition, let us say that deserts are lands where agriculture and settlement are impossible without special facilities for securing water. Every geographer can recognize a desert when he sees one; it is only the gradations and periphery which make classification difficult.

Millions of square miles are dry; here life exists only under specialized conditions. How large are these areas? At least a quarter of the land surface is arid; maybe a third. Along the humid borders, and within the dry lands where water is available, are many tempting possibilities for cultivation.

Most of Australia is dry, some of it "never never" country. The Sahara and the Sudan cover much of North Africa, and are matched by the Namib and Kalahari deserts in the south. Asian deserts reach from the Arabian Peninsula across Soviet Middle Asia into northern China, and include such nearly rain-

FIG. 4. Oases represent a precarious base for livelihood where bordered by shifting dune sands. This view adjoins the palm grove shown in Figure 3. (*G. B. C.*)

less areas as the Taklamakan Desert. South America has the equally dry Atacama, plus the Patagonian steppes. North America, west of the 100th meridan includes a succession of dry lands, where water is scarce. We often forget that the polar areas are physiological deserts.

Deserts do not "stay put." Instead, they expand and contract with fluctuations in climate. The Great Wall of China was built to set the limits between the wandering nomad and the settled agriculturalist, in other words, to define the Koeppen "BS" boundary. Yet several times since its construction the Mongolian steppe has become subhumid, say "Dwa," and Chinese farmers have pushed a hundred miles north of the Wall. In other centuries "BS" desert conditions have spread far south into the Yellow Plain so that the Mongols, perhaps faced with abnormal aridity in their homeland, have burst through the Wall to overrun interior China.

The same problem exists in our own semi-arid west. This is by nature a short grass area suitable for grazing; in years when the steppe is momentarily more humid man is tempted to bring in the plow. Then when rainfall drops off, crops fail and dust blows.

Man sometimes thinks that he has conquered and pushed back the desert, but time may prove otherwise. Witness successive settlement and abandonment in the American Dust Bowl, and similar shifts along the Soviet dry frontier in the steppes of the Ukraine and the Lower Volga.

COMPETITION FOR WATER

Under ideal hydrographic conditions, a geographer may suggest that no drop of rain should run off to the sea without having done something useful for man; preferably it should serve multiple functions. These services may represent consumption by man, provision for navigation, or the use of water to carry away sewage or to generate power. Increasingly there is competition between rival demands for urban and industrial use as compared with irrigation needs. And within the agricultural

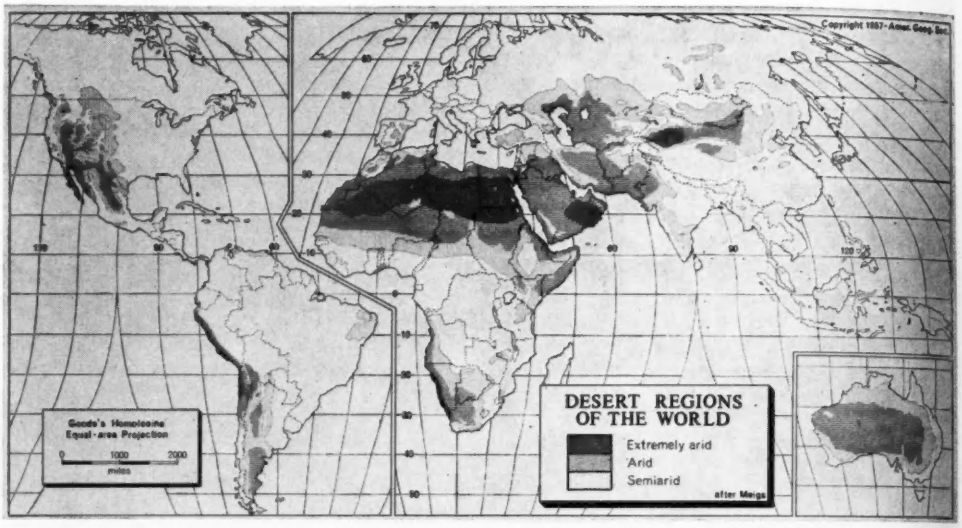

FIG. 5. Large parts of the world are too dry for normal settlement; here life depends on precarious supplies of water. (*Courtesy of* Focus, *Vol. VII, No. 5 [Jan. 1957] published by the American Geographical Society.*)

field there is competition between truck vegetables and field crops.

There is also competition between upstream and downstream users. Egypt needs the Nile, but what would happen if the Sudan should divert an undue proportion? Similar problems in the Indus Basin arise between India and Pakistan. The people of Iraq become quite excited over proposed irrigation schemes along the Euphrates in Syria which might subtract large amounts of water now available for their use.

The United States will face a similar problem along the Rio Grande when Mexico demands its share of the water now used on the Texas side. There are also problems on the Colorado where California's claim to 5,362,000 acre-feet is disputed by Arizona, which is currently asking the Supreme Court for 1,500,000 acre-feet. In this lawsuit, pending since 1952, California's claim is based on an old Roman code which specifies that "who is first in time, is stronger in right"; whereas Arizona bases its case on riparian rights.

Rivers which lie along international boundaries often create problems. Witness the Jordan River and the irrigation plans of Israel.

Since much of the Islamic world is arid, it is not surprising to find a large body of Moslem law on water rights.[4] Thus the Koran gives precedence to users upstream who have the right to divert as much as they require. Such a rule for the Euphrates would give priority to Syria over Iraq.

So much has been written about irrigation along the Nile that it may be worth while to compare it with the Tigris and Euphrates. Conditions in the two basins are not the same. Until a century ago, irrigation in Egypt was of the field type, with units of several thousand acres flooded for a month or two. This annual inundation dissolved and carried away any salt. Today most of the area receives perennial irrigation, supplied both from canals and wells. This has raised the water table, brought deep-seated salt to the surface, and has made it necessary to install drainage ditches. Whereas the Nile silt is derived from fertile top soil in forested headwaters, the Tigris and Euphrates derive much of their sediment from infertile semiarid lands. The floods of the Nile arrive in the fall before the planting season, while the Tigris and Euphrates reach their peak in spring just prior to the hot summer.

[4] Food and Agriculture Organization of the United Nations, "Water Laws in Moslem Countries" (Rome, 1954).

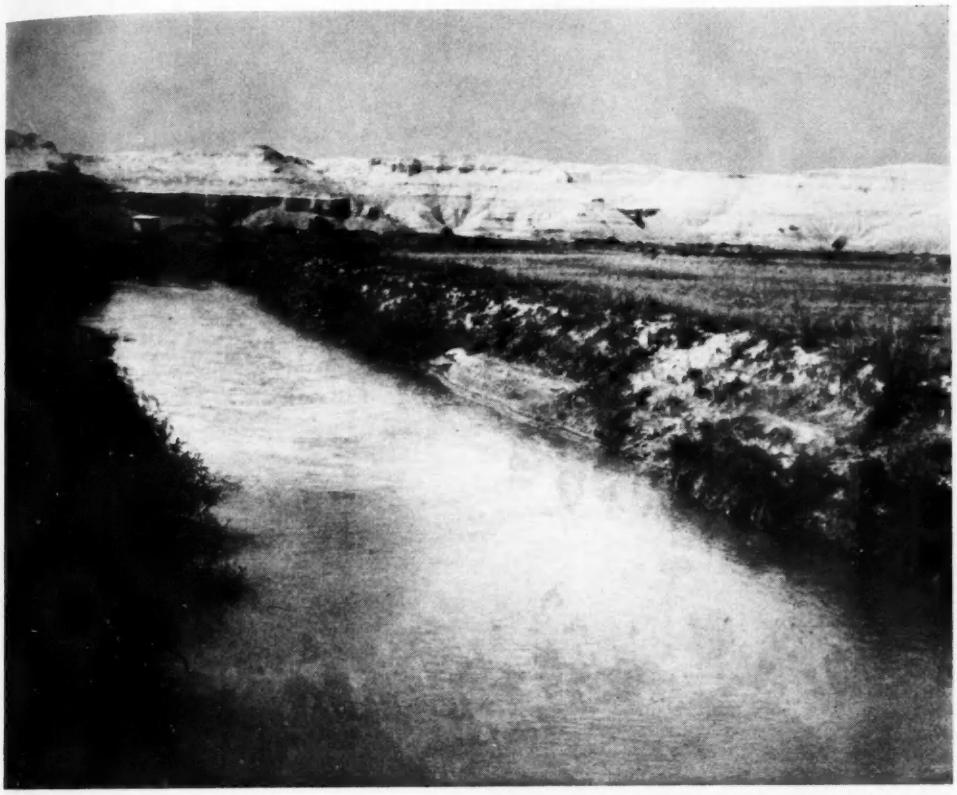

FIG. 6. The Jordan River, here seen at the Allenby Bridge not far from the Dead Sea, is so small a stream that even if used entirely it would irrigate only a limited area. (*Courtesy Iraq Petroleum Company.*)

Even if desert water is available, there is the problem of economic utilization. A donkey or a camel may lift water some tens of feet in order to irrigate a field, but when the harvest comes a part of the crop must be set aside for his food. The deeper the well, the greater the share. At Grand Coulee on the Columbia River, water is lifted 300 feet, and the cost is near the economic limit. Such economic questions may be the limiting factor along rivers such as the Euphrates in Syria where extensive unused uplands fringe the river. The key questions concern the cost of power and the dependable supply of water.

Camels are justly famous for their adjustment to aridity. Where forage plants contain sufficient amounts of moisture the camel may become completely independent of drinking water. Camels which have been without water for two months in winter may refuse it when offered. In summer the situation is different. While man in a hot desert keeps his body at an even temperature through the evaporation of up to 15 quarts of water a day, the camel is able to stand a variation in his body temperature of as much as 10 degrees F. Camels are also able to withstand exceptional dehydration of the body, twice the percentage possible in man. Thus, when thirsty, they may take in 30 to 40 gallons at a time.

HYDROLOGY IN DRY LANDS

There is a major difference between stream flow in humid and arid lands. In areas of abundant rainfall and normal humidity, rivers become larger and larger as they flow onward to the sea. Both tributaries and inflow from ground water add to their volume. Where rivers cross deserts they progressively lose water by evaporation and by subtraction

FIG. 7. Floods on the Tigris are to be partially controlled by this new dam at Samarra which will divert surplus water into the Wadi Tharthar depression. (*Courtesy Iraq Petroleum Company.*)

for irrigation. Hence desert rivers wither, and less water enters the sea than emerges from the parent highlands. Since withering rivers are also depositing rivers, they tend to flow on a low ridge. This simplifies diversion for irrigation, but also leads to flood hazards.

So extensive is this loss of water that many desert streams never reach the ocean, or even a terminal salt lake. This is the case in the American Great Basin, in Chinese Sinkiang, and the Atacama Desert. We think of rivers as carrying fresh water; this is assumed. But where withering rivers have lost most of their volume, the original chemical load is concentrated in the remaining water. Hence streams in Kazakstan flow salty.

The most extensive oases are found where exotic rivers cross arid lands, bringing water from distant snow mountains. In this group are the Nile, the Amu and Syr Darya, the Colorado, the Rio Grande, and the three rivers which converge to form the Shatt al Arab: the Euphrates, Tigris, and Karun.

Just as Egypt is "the gift of the Nile," so life in most of Iraq is the product of the Tigris and Euphrates. These rivers, rising in Turkey, are joined by the Iranian-born Karun to form the Shatt al Arab, the river of the Arabs.[5] To the north of Iraq lie the Taurus Mountains; on the east are the Zagros. These are high mountains with many peaks in excess of 10,000 feet. Even in the early summer they have a heavy snow cover. Precipitation data are inadequate, but the figure exceeds 40 inches in the mountains as compared with 5 inches on the plains.

The entire basin of the Shatt al Arab covers 808,304 square kilometers. Within it the total

[5] See forthcoming article in *The Middle East Journal.*

FIG. 8. When the Tigris breaks its banks, large areas are inundated. This view is in the outskirts of Baghdad. (*Courtesy Iraq Petroleum Company.*)

annual rainfall amounts to some 325.8 cubic kilometers. What happens to this water? There are no discharge measurements in Turkey or Syria, but when the Tigris, Euphrates, and Karun reach their alluvial plains, after the last major tributaries are past and before much water has been withdrawn for irrigation, the combined flow amounts to only 90.5 cubic kilometers. In other words, out of the 325.8 cubic kilometers received from precipitation, 235.3 have been lost by evaporation. Much of the limited rain which falls in the desert never reaches a permanent stream. Some seeps into the ground but reappears later.

Further losses occur downstream. Scores of irrigation canals take off water. Vast swamps near the head of the Persian Gulf soak up as much more. Whereas the mean December flow past Baghdad is 709 cubic meters per second, or cumecs, 250 miles downstream the discharge shrinks to 64 cumecs. In other words, nine-tenths has been lost en route.

Around the junction of the Tigris and Euphrates is a large area of swamps and lakes known as the Inland Delta. This area has a combined intake from the rivers and local rainfall of 56 cubic kilometers. Of this total, 33 are evaporated, while 23 flow on to the Shatt al Arab. When the combined flow of the three rivers finally enters the Persian Gulf, the annual discharge amounts to only 27 cubic kilometers.

The water budget of the system, in cubic kilometers, thus reads as follows: receipts from precipitation: 325.8; losses above the delta (largely pre-river evaporation): 235.3; losses below the head of the delta (half diversion for irrigation and half absorption

into swamps, both mostly evaporated): 63.5; final discharge into the sea: 27.

If all of the water which enters Iraq might be controlled and properly used, millions of desert acres could be cultivated, providing food for twice the present population or more.

These figures from Iraq may be compared with data for the Ohio River. The basin of the latter is only two-thirds as large but its discharge into the Mississippi is ten times as great. Virtually all the water flowing past Cincinnati reaches the ocean, whereas the water passing Baghdad has only a one in twenty chance of joining the sea.

The water budget may be put in another way. Most of Iraq has an annual rainfall of 5 to 10 inches, in comparison with evapotranspiration figures of 50 to 70 inches. To meet this deficit, the country imports from Turkey, Syria, and Iran enough water to add 6 inches, or half an acre-foot, if spread evenly over the entire country. Although this doubles the available moisture, it is quite inadequate to close the gap. Since in any case such an even spread is impractical, the available water is used intensively in irrigated lands below Baghdad and Ramadi.

SALT

The loss of water through evaporation is only a part of the story. Each of these rivers carries a chemical load. That in the Tigris averages 250 parts per million; the Euphrates carries 445 p.p.m. The lowlands of Mesopotamia have long been a subsiding geosyncline, often arid and at times partly landlocked. The accumulated sediments include large amounts of salt, gypsum, anhydrite, and other evaporites. Hence the ground water contribution to the present rivers is abnormally saline.

The usable limits of brackish water depend on its chemical composition and on the tolerance of man, animals, and vegetation. Desert people can drink water with a chemical content of 3,000 parts per million without serious

FIG. 9. Salt is a hazard in all irrigated lands, especially in flat areas with poor subsurface drainage where a high water table permits capillary action to lift moisture to the surface. This is a view near the Tigris in southern Iraq. (*G. B. C.*)

effects, and even up to 5,000 p.p.m. for short periods. This compares with American municipal water which may have as little as a few tens of p.p.m. Cattle can tolerate 9,400 p.p.m., and sheep up to 15,600 p.p.m. On the other hand, the maximum chemical content for irrigation is only 740 p.p.m., or 1 ton of salt per year per acre-foot of water.

Even small amounts of alkali and sodium carbonate can make water unfit for irrigation since they produce a dense impervious layer. To remove this it is necessary to add calcium sulphate, or gypsum, until the sodium is converted to soluble sodium sulphate.

As the Tigris and Euphrates lose water, the original chemical load is concentrated in that which remains. When the water evaporates salts are precipitated. Water losses through evaporation on the agricultural lands of Iraq are estimated as 37 cubic kilometers. At an average concentration of 300 parts per million, this means an annual increment of 22,000,000 metric tons. About a fifth of this is sodium chloride, a third gypsum, and the balance calcium carbonate. Iraq is thus a vast salt factory, perhaps the largest on earth. Billions of tons of soluble precipitants await transport to the sea. Like Lot's wife, large areas have turned to salt.

This accumulation has proceeded, in one region or another, for centuries. As a result vast areas have been ruined for agriculture. In many places the surface is coated with a snow-like efflorescence. Local depressions contain a crust of precipitants. Elsewhere the root zone of the soil contains high percentages of salts.

It was suggested earlier that geographers should prepare water budgets; it is equally true that there needs to be an accounting for salt intake and outgo. Rain water is nearly pure but as it enters the ground it takes on a chemical load. The longer it remains underground, especially where it passes through ancient evaporites, the higher its salinity. Where irrigation water is supplied by streams which rise in humid areas, the salt content may be low, but where irrigation depends on local well water the percentage may be prohibitive.

The salt budget begins with an analysis of the soil and the ground water, and proceeds to the character of the irrigation intake. Current use is represented by the requirements of vegetation and by accumulation due to evaporation. The latter is closely related to the height of the water table, the permeability of the soil and the character of the surface.

Finally comes an analysis of the amount and composition of the drainage water in order to find how much of the chemical load has been left behind. Where soils are gaining in their salt content, look out. In comparison with a saline concentration in the Tigris and Euphrates of 250 and 445 p.p.m., respectively, the Shatt al Arab in its diminished flow averages 746 p.p.m. This does not imply that more salt is removed than is brought in; rather the reverse, when one considers the relative volumes of water.

The failure to establish a salt budget may be illustrated from an ambitious development program now under way south of Baghdad, known as the Dujaila Project. This lies on the flat delta of the Tigris in an area of clay soils. Hundreds of miles of canals were dug, and it was proposed to irrigate a large area. Settlers were brought in, and during the first year there were good harvests. With the introduction of irrigation, the water table rose and some areas became waterlogged. The higher water table permitted capillary action to raise moisture to the surface where it evaporated and left behind its chemicals. This concentration approached the tolerance limit for crops, and yields declined. Within a few seasons so much salt had accumulated near the surface that parts of the project have been abandoned. No soil surveys were conducted prior to the inauguration of the project. When made later on, it developed that many samples carried 3 percent salt in the top 18 inches, with some measurements to 17 percent.

After the Dujaila Project was completed, it was recognized that it is just as necessary to plan for the removal of water as it is to supply it. The total costs had already approached economic limits, but to salvage the project it was decided to dig drainage ditches. These are 4 to 5 feet deep, spaced at intervals of 50 yards. Since the land is nearly flat, the seepage must be pumped into the nearest stream. This drainage water carries from 5 to 10 percent salt, thus up to three times the content of the ocean. The digging of these

FIG. 10. Many desert wells are of great antiquity, and in some cases are more than a hundred feet deep. The deep grooves around the encircling stones reflect long Bedouin use. (*Courtesy Arabian American Oil Company.*)

drainage ditches is not the only expense, for they remove 10 percent of the area from cultivation and change farming techniques.

This failure to deal with salt can be duplicated elsewhere in many places. An example of the 1930's lies in China at the northeast bend of the Hwang Ho, in the province of Suiyuan, where it was proposed to irrigate 330,000 acres. The canal system is clearly shown on many maps. Within a short time, the area became waterlogged and overly saline, and was largely abandoned.

West Pakistan has large areas of irrigated land. It was reported in 1957 by John Bell, Director of the United States International Cooperation Administration, that 50 percent of the irrigated area is affected by increasing amounts of crop-destroying salt. In the Punjab, 14,000,000 acres are under irrigation, of which 3,000,000 acres are badly affected by salinization or waterlogging, of which 1,300,000 acres have been withdrawn from cultivation.

Since most soil salts are soluble, it is quite possible to flush out the saline materials, but this takes large amounts of water and considerable time. Such is the result of the failure to set up a salt budget. How long before administrators will realize that wise planning is impossible without completing the geographic inventory. The price of geographic ignorance can be very high. (Baghdad papers please copy.)

SILT

Without carrying budget accounting too far it may be pertinent to add the problem of silt.

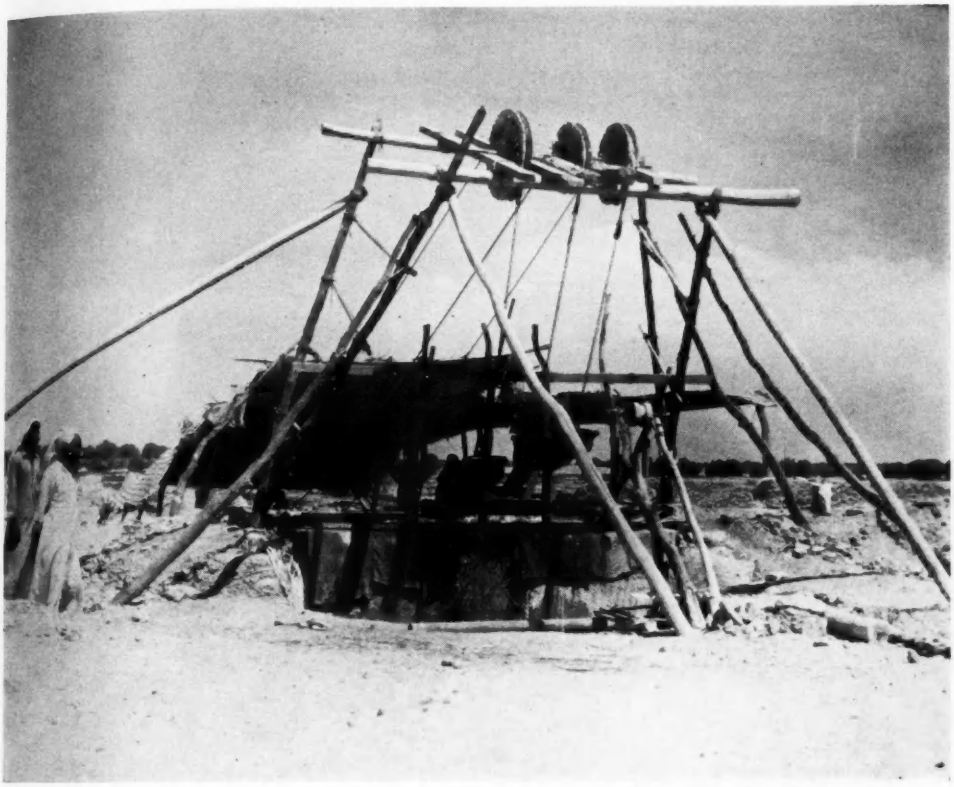

FIG. 11. Where large amounts of water are to be drawn from desert wells, either for irrigation or to supply animals, leather buckets are lifted by donkeys who walk down an inclined plane while pulling a rope. (*Courtesy Iraq Petroleum Company.*)

Excessive amounts accumulate in irrigation canals. Desert rivers usually carry large volumes of sediment, particularly in their bottom load; this must be kept out of canal systems. How much silt is brought into an area by the rivers, and from what sources? How much is carried to the sea? What happens to that left behind? Although much of the water of the Tigris and Euphrates is diverted into canals, nowhere are there any desilting basins.

GROUND WATER

Perhaps we have looked at water in the desert too much on the surface, and not enough from below. Just as plants in arid lands grow "upside down," in that the bulk of the plant is below ground for a better adjustment to the climate, so ground water hydrology may be more important than that of surface water. Along with maps of precipitation we need three-dimensional maps for the contour and composition of underground waters. Different levels have different character, and there is both horizontal and vertical circulation. Since we cannot readily see or measure water below the surface, we often overlook these differences. While this is true the world around, the importance and complexity of ground water hydrology increases with aridity.

Most desert rain never penetrates to the water table, often no more than 2 or 3 percent, depending on soil characteristics and the concentration of rainfall. In fact, much rain may be evaporated into the thirsty air on the way down; one may watch torrents of rain descending from high cumulus clouds yet

FIG. 12. The ruins of Palmyra, in central Syria, include ancient aqueducts and other archaeological evidence that aridity was a problem in Roman times as now. (*Courtesy Iraq Petroleum Company.*)

little or none reaches the ground. Much of that which does sink into the ground remains in the upper few feet, soon to be used by plants or lost by evaporation. Only a small fraction of the runoff actually reaches the nearest permanent stream, perhaps 5 percent. The bulk of desert rain disappears through evapotranspiration soon after it falls.

If more of the scanty rainfall could be encouraged to sink into the ground, either where it falls or down slope through water spreading, it would be a major asset since such underground storage involves little loss through evaporation. In contrast, storage in desert reservoirs may involve evaporation figures of 50 to 70 inches per year.

While the total precipitation in a desert is low, so much of it quickly returns to the atmosphere that one wonders about the conventional assumption that desert rain is imported from some distant ocean.

Ground water is dangerous if it does not move. The essential requirement in dry lands is to keep the net movement of soil moisture downward. This means progressive leaching in contrast to concentration. Whenever rain or irrigation water penetrates only a few inches into the soil, or where the water table is within five feet of the surface, capillary action moves moisture upward until it evaporates.

Water of suitable irrigation quality can rarely be found in a desert where wells depend on the local rainfall, since desert ground water is usually too saline. The few exceptions are where a veneer of fresh water may float, unmixed, on top of brackish ground water, or where there is a perched water table. Overpumping often leads to increasing salin-

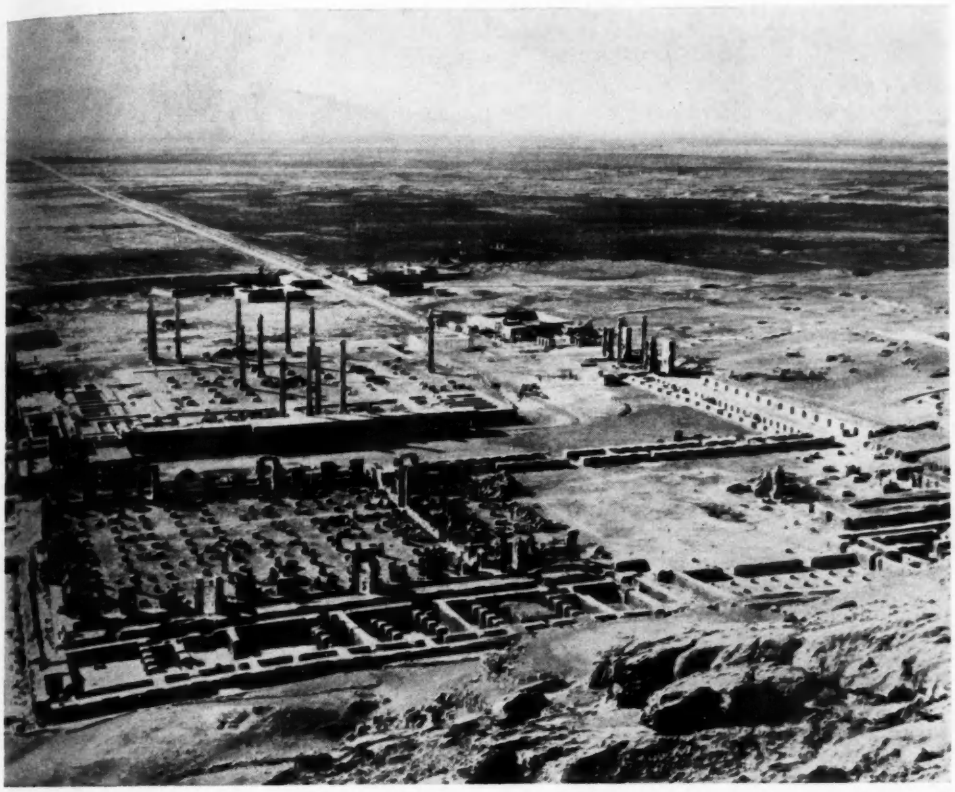

FIG. 13. Ancient Persepolis, founded by Darius five centuries before Christ, lies in the semiarid plains of Iran. Cisterns and conduits for water lie beneath the ruins. (*Courtesy Iranian Oil Consortium.*)

ity. Fresh water seeps are sometimes found around the margins of sand dunes which rest on impervious formations.

All of this suggests the danger of irrigating flat delta lands with their tight soils and poor drainage. Canal construction may be easy but it may cost more to get rid of the water than to bring it in. Instead, irrigation is safer on sloping uplands with good subsurface drainage conditions, such as alluvial fans or erosional plains. Even in deserts these are apt to be salt free and have a good soil structure. Vast sums have been wasted, the world around, in trying to irrigate the wrong soils. Some desert soils tend to be alkaline, and if the irrigation water adds exchangeable sodium it may reduce their permeability by producing a tight impervious layer and so reducing subsurface drainage.

In place of the conventional surface irrigation from canals, it may be feasible to arrange for subsurface irrigation through a system of pipes. This will enable water to be applied at the proper depth where capillary action will lift moisture to the root zone but will keep the surface dry.

DESERT PROSPECTS

Have deserts always been deserts, at least within historic times? During the past year I had the opportunity of visiting many centers of ancient culture, such as Babylon, Palmyra, and Persepolis. One is indeed impressed by the magnificence of these desert ruins, but in each case it is clear that water shortages were a problem in ancient times, much as now. Old aqueducts, cisterns, and kanat systems show that the occupants had to face problems of aridity not much different from those of today. There have surely been fluctuations

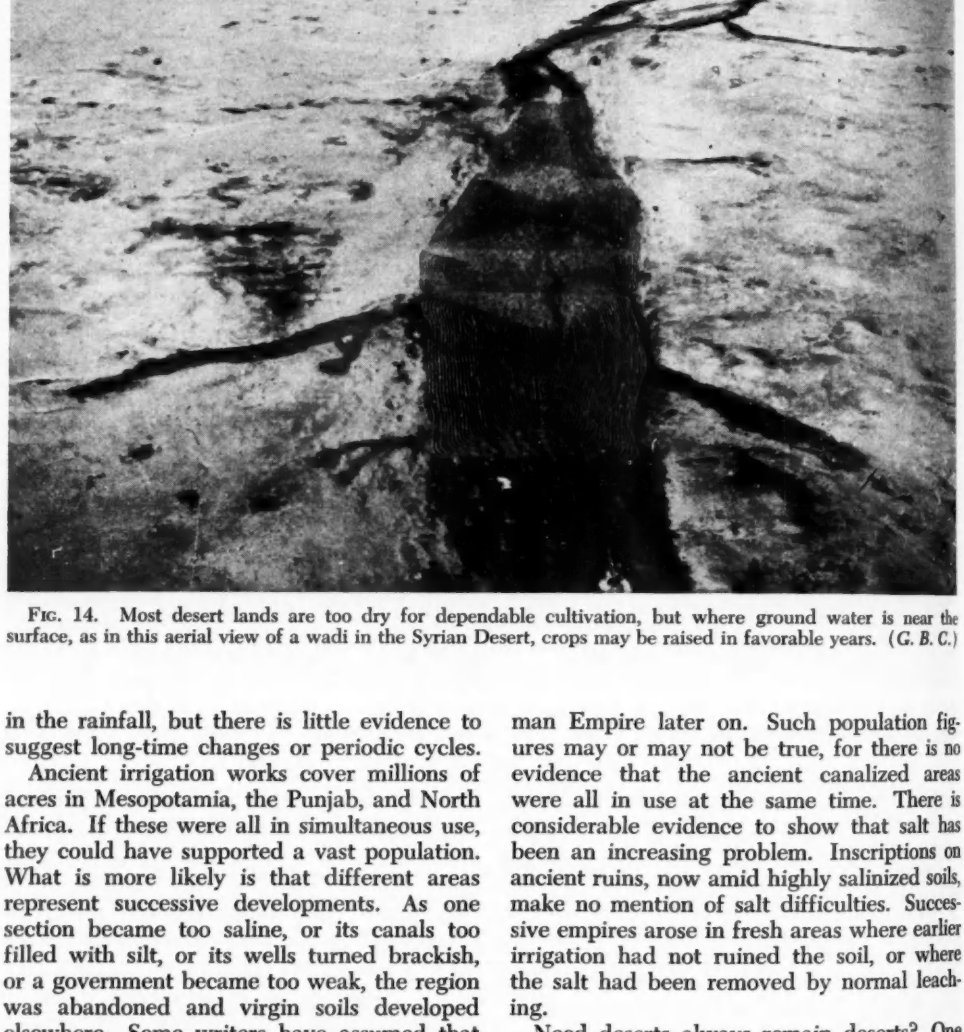

FIG. 14. Most desert lands are too dry for dependable cultivation, but where ground water is near the surface, as in this aerial view of a wadi in the Syrian Desert, crops may be raised in favorable years. (*G. B. C.*)

in the rainfall, but there is little evidence to suggest long-time changes or periodic cycles.

Ancient irrigation works cover millions of acres in Mesopotamia, the Punjab, and North Africa. If these were all in simultaneous use, they could have supported a vast population. What is more likely is that different areas represent successive developments. As one section became too saline, or its canals too filled with silt, or its wells turned brackish, or a government became too weak, the region was abandoned and virgin soils developed elsewhere. Some writers have assumed that these ancient civilizations represent a more humid climate, but again the evidence is poor.

It has sometimes been stated that Mesopotamia was once a fertile land, with perhaps six times its present population. The destruction of the vast irrigation system which was supposed to have produced this garden is blamed on the invading Mongols in the eleventh century, and the failure to re-establish irrigation is laid at the door of the Ottoman Empire later on. Such population figures may or may not be true, for there is no evidence that the ancient canalized areas were all in use at the same time. There is considerable evidence to show that salt has been an increasing problem. Inscriptions on ancient ruins, now amid highly salinized soils, make no mention of salt difficulties. Successive empires arose in fresh areas where earlier irrigation had not ruined the soil, or where the salt had been removed by normal leaching.

Need deserts always remain deserts? One has only to look at the Imperial Valley and the many other American oases to find a partial answer. Where water is available, the desert indeed blossoms as a rose. Perhaps it should be pointed out that Biblical references to desert roses really refer to the crocus, a plant better adjusted to long periods of quiescence and rapid recovery after the rains.

Few parts of the world are more lifeless or impenetrable than the vast sand wastes of the

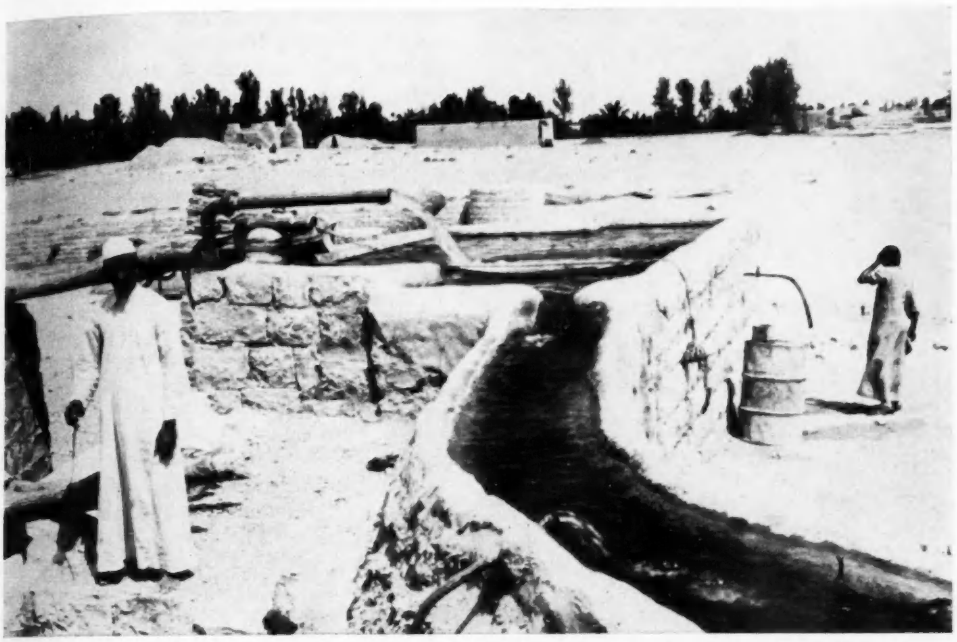

FIG. 15. Modern diesel pumps supply water for irrigated gardens around the city of Riyadh, capital of Saudi Arabia. Overpumping often depletes the limited reserves. (*G. B. C.*)

Rub al Khali. Yet last summer I ate fresh lettuce and other vegetables there, and enjoyed all the luxuries of civilization when I visited an oil outpost. In contrast, the poor Bedouins who live around the margins of the Rub al Khali subsist on milk and a few dates.

The capital of Saudi Arabia, Riyadh, lies along the Wadi Hanifa which rarely carries much water. Few large cities have a poorer location so far as water is concerned. Fortunately, deep wells, diesel pumps, and a new pipe line provide a modest supply for this artificial oasis. This water, plus the magic of oil, is now making it possible for $250,000,000 worth of handsome buildings to be under construction.

One of the most striking experiences of air travel is to pass abruptly from the green of an oasis to the brown of the encircling desert. This is a knife-edge boundary, whether seen from a plane or on foot. Jump across the outermost irrigation ditch and one passes from rich alfalfa to bare sand. Millions of people are now raising cotton or citrus fruits where once grew cactus or sage brush. Areas which once exported a few bales of wool now ship trainloads of vegetables. The Sukkar Barrage on the Indus has transformed five million acres of the Thar Desert into good farm land. Perhaps nowhere in the world are so many people dependent on irrigation as in West Pakistan.

This year marks the one hundred and tenth anniversary of irrigation in the United States. On July 24, 1847, the Mormons began cultivation near Salt Lake City. "Having planted a few acres, they turned the water from the creek upon their little field and gave the soil a 'good soaking.' This was the beginning of their (ultimately) vast and successful system of irrigation, since famous throughout the world."[6] Some of the irrigated areas in Utah had adequate slope and subsurface drainage, but where these were lacking, the land soon became waterlogged, and soil salinity developed so that much land has already gone out of production.

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[6] Charles Langdon White, "The Agricultural Geography of the Salt Lake Oasis," *Journal of the Scientific Laboratories,* Denison University, Vol. 21 (1925), p. 123.

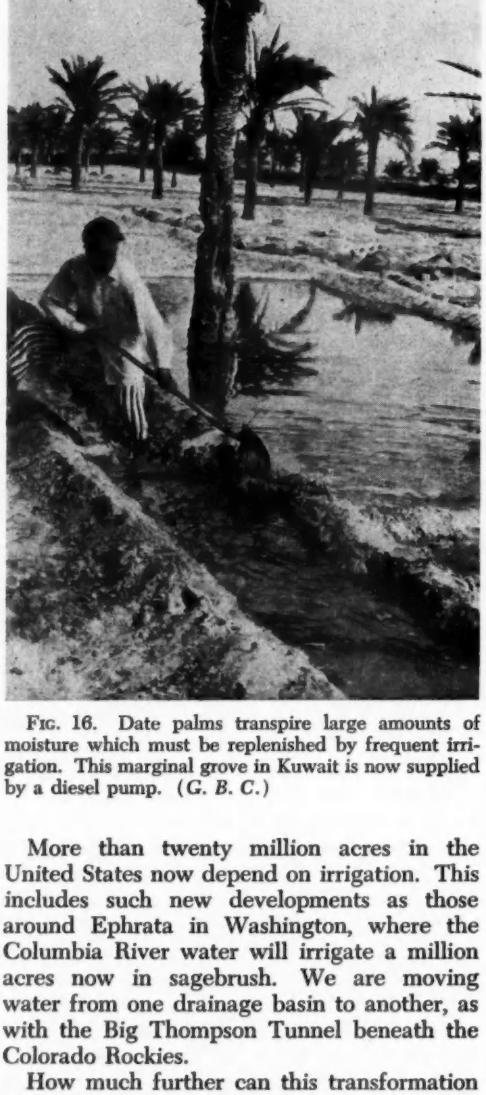

FIG. 16. Date palms transpire large amounts of moisture which must be replenished by frequent irrigation. This marginal grove in Kuwait is now supplied by a diesel pump. (*G. B. C.*)

More than twenty million acres in the United States now depend on irrigation. This includes such new developments as those around Ephrata in Washington, where the Columbia River water will irrigate a million acres now in sagebrush. We are moving water from one drainage basin to another, as with the Big Thompson Tunnel beneath the Colorado Rockies.

How much further can this transformation of the desert be carried? Water holds a large part of the answer; both more water and a better use of that now available. If all wasted runoff could be stored underground or in new reservoirs, if evaporation losses could be reduced, if irrigation canals were better lined to reduce seepage, and if only the right amount of water were applied at just the right time, the irrigated land of the world might be doubled and more. Even this would account for only a small fraction of all deserts. With proper land management, insect control, and better seeds, productivity could be greatly increased.

There are some hopes that we may eventually purify sea water at a reasonable cost, but even if the ocean were fresh to begin with, the cost of pumping it onto desert uplands might prove uneconomical. Present costs of desalinization are several times as much as irrigated lands can afford. Kuwait is able to distill two million gallons of sea water a day for domestic consumption, but only because of free gas.

Provided that ample supplies of water are available at low costs, desert agriculture offers many advantages. Soils are usually well supplied with unleached mineral nutrients. Sunshine is abundant, temperatures are generally high, and crops may be raised several times each year. This is made possible by a regulated water supply, especially where just the right amounts may be provided at just the right time. As a result, values of irrigated land are relatively high.

Land, water, and life in dry lands are in delicate balance. Where the dry steppe becomes overgrazed the ensemble of vegetation may be so changed that it will require decades to recover. The collection of brush and roots for fuel have also denuded large sections. Perhaps nowhere in the desert can we photograph any "natural" vegetation. Vast areas of steppe lands have become man-made deserts.

Where new supplies of water become available, life suddenly appears. The Trans Arabian Pipeline crosses a nearly empty area of northern Arabia, one where Bedouins were rarely seen. One of the agreements with the government was that the pump stations would supply water to such nomads and their camels as should appear. Two summers later, the station at Turaif was called upon to water 25,000 camels, and for five months the requirements averaged 10 million gallons a month. Waste water from the pump station now irrigates vegetable plots, the only spot of green for a hundred miles.

KANATS

No account of water in the desert can be complete, at least for Southwest Asia and

FIG. 17. The availability of water from deep wells along the Trans Arabian Pipeline has attracted great numbers of nomads with their flocks. This encampment is at Badanah. (*Courtesy Arabian American Oil Company.*)

North Africa, without reference to the infiltration tunnels known as kanats.[7] These unique irrigation systems are of Persian origin, and are also known as karez or foggara. Kanats are best developed in Iran, but are found from Chinese Sinkiang to the Atlas Mountains, and even in the New World, where they were introduced by the Spanish, who in turn learned the method from the Arabs.

Kanats represent a simple device for bringing ground water to the surface by gravity. They consist of a nearly horizontal tunnel, often miles in length, which leads up-slope along the radius of an alluvial fan until the water table is tapped. At this upper end the kanat tunnel may be tens or even hundreds of feet below the surface of the ground. In order to dig the tunnel, shafts are sunk every 50 to 100 yards, and the soil is piled around the mouth of the shaft in a doughnut-like mound.

While kanat construction is expensive, and occasional cleaning is necessary, the water flows freely the year around. Thousands of villages and large agricultural areas derive their sole supply from these kanats. It has been estimated that they provide water for a third of all the irrigated land in Iran. Drilled wells and diesel pumps are gradually taking their place, but these tend to exhaust ground water reserves faster than they accumulate.

GEOGRAPHIC INVENTORY

Wise planning calls for a geographic interpretation of the water budget for each drainage basin, whether in the desert or elsewhere. Just as an individual must plan for his finan-

[7] See a forthcoming article by the author in the *Geographical Review*, April 1958.

FIG. 18. Lines of circular mounds mark the shafts which lead to the underground tunnels known as kanats. Many shafts are closed to prevent damage from occasional rains. This aerial view is west of Kirkuk, Iraq. (*G. B. C.*)

cial needs, so we should plan for water. This must be done in terms of maps as well as statistics. Some of us in academic life are accustomed to ten pay checks, leaving an arid interval. In desert hydrology, conditions are reversed with a few days of income and a long, long period of living off the accumulation—if any.

A geographic appraisal of the water balance should begin with an evaluation of its present capital assets. This refers to the amount and character of the ground water resources. Few deserts are entirely without deep-seated reserves, but very often they are too saline for crops or man.

Next comes an estimate as to annual income. In humid lands, as with well-established individuals, this is a fairly predictable item but in a desert the rainfall will vary within wide limits. How much of the rainfall should ideally be allocated to runoff, to ground water storage, or to other uses? Individuals occasionally receive windfalls, as in the death of a rich aunt; so arid lands have phenomenal cloudbursts which bring catastrophic results, perhaps once in a decade or once in a century. In both cases the sudden income creates problems.

Normal water needs, such as the requirements for vegetation and evaporation, correspond to current expenditures in a family. Wise people try to live on their income and avoid future commitments; so too any sound planning for agricultural expansion should weigh past realities and not gamble on uncertain future assets. If there are occasional windfalls, either from the rich aunt or the infrequent cloudburst, a part should be invested either in securities or in ground water recharge as a safeguard against the rainless years which are sure to come.

The water budget for an arid region must look ahead at least 20 or 30 years; 5 years are not enough. Bridges planned only for normal river flow will surely be carried away by unexpected floods. Long intervals without rain are certain to occur but are unpredictable. One's bank may permit modest overdrafts, but when an area is caught with inadequate rain for a series of years, nature is inflexible. Without water, vegetation dies and man must migrate, turn bandit, receive charity, or starve.

An understanding of water in the desert requires the cooperation of many disciplines: climatology, geomorphology, hydrology, soil science, agriculture, and engineering. Much of the detailed fact-finding must come from such specialties; it is the responsibility of the geographer to correlate the data.

So far ahead as we can see, deserts will remain deserts and water shortages will continue. Desert cities will grow, and agricultural oases expand, but the nomad will still find his life precarious. Arid lands have their limitations, and man presses against these at his peril. The contribution of geography is to integrate and weigh all the factors, physical and cultural, and to present a total budget of assets and liabilities. Wise planning is impossible without a sound geographic inventory.

CLIMATOLOGY: COMPLEX, DYNAMIC, AND SYNOPTIC

ARNOLD COURT
University of California, Berkeley

Dynamic climatology and *synoptic climatology* are similar terms which have been confused often by persons who did not understand the different intentions of the originators of these two terms. *Complex climatology* is an even older term, little used although it applies specifically to some studies which have been called, erroneously, dynamic or synoptic. Origins, definitions, applications, and uses of these three aspects of modern climatology are offered in this paper.

Each of these approaches endeavors to consider the totality of weather, during a short time interval, as a unit. Advocates of each decry "static" climatology in which the individual elements are treated separately. The methods and procedures of these approaches differ materially, despite certain similarities and parallels. *Purpose*, however, is the primary basis of distinction. Fundamentally, each approach is intended for a different user, each with different requirements and hence demanding three distinct ways of analyzing meteorological observations.

This investigation of these three climatic methodologies began in a survey of existing methods of climatic analysis undertaken as part of a study for the RAND Corporation of Santa Monica, California. It was resumed in hopes of sharpening the definitions in a glossary of meteorology being prepared by the American Meteorological Society, and to comment upon two papers: one by Hare, attempting to draw a distinction between dynamic and synoptic climatology,[1] the other by Gordon, seeking to define the domain of a World Meteorological Organization working group of which he was chairman.[2] A preliminary version of the present paper was reproduced by the RAND Corporation (as its No. P-769, 22 Nov. 1955) and circulated to nearly a score of climatologists throughout the world, including most of those who had originated and developed the methods under discussion. Many of their welcome comments have been incorporated into the slightly revised version presented here.

[1] F. Kenneth Hare, "Dynamic and Synoptic Climatology," *Annals*, Association of American Geographers, Vol. 45 (1955), pp. 152–162.

[2] A. H. Gordon, "Dynamic Climatology," *W.M.O. Bulletin*, Vol. 2 (1953), pp. 121–124.

COMPLEX CLIMATOLOGY

Oldest of these three procedures, in name if not in origin, is complex climatology, first proposed specifically by Federov before a Russian scientific meeting in 1921, published in Russian in 1923, and expounded in German in 1927; a summary and discussion of the German paper appeared in the *Monthly Weather Review* in 1927.[3] Further details were given by Federov in an illuminating pamphlet published by the New Jersey Department of Agriculture.[4] Federov continued the development and exposition of complex climatology in Russian and in German.[5] His chief disciple, Chubukov, lists 21 works by Federov and has continued the applications.[6]

Complex climatology is purely objective. It uses only the weather observations made at a given place, classified into *weather types*.

[3] E. E. Federov, "Das Klima als Wettergesamtheit," *Das Wetter*, Vol. 44 (1927), pp. 121–128, 145–157; condensed translation by Esek S. Nichols, with comments, "Climate as Totality of the Weather," *Monthly Weather Review*, Vol. 55 (1927), pp. 401–403.

[4] Federov, *A Complex Method in Climatology and Its Application to Agriculture*, Circular No. 207 (1932), New Jersey Department of Agriculture, 32 pp.

[5] Federov, "Beispiel eines Vergleiches der Klimate zweier Ortslagen mit Hilfe der komplexen Methode. (Sloutzk und Djetskolje Sjela.)," *Meteorologische Zeitschrift*, Vol. 38 (1931), pp. 306–314; "Die Beziehungen zwischen dem Ernteertrag und der Entwicklungsdauer von Feldpflanzen und der 'klimatischen' Wettertypen," *Bioklimatische Beiblätter*, Vol. 1 (1934), pp. 166–170; "Feldkultur und Klima, bewertet nach den Methoden der komplexen Klimatologie," *Bioklimatische Beiblätter*, Vol. 3 (1936), pp. 16–20; "Die Verbreitung der Wettertypen des Ssukhoveji in der Ebene des europäischen Teils der Sowjet Union," *Bioklimatische Beiblätter*, Vol. 3 (1936), pp. 128–133.

[6] L. A. Chubukov, *Kompleksania Klimatologiia* (Moscow: Akademiia Nauk, 1949), 94 pp.; *Novoe v Uchenii o Klimate* (Moscow: Izdavo "Pravda," 1949), 24 pp. (Both references from *Meteorological Abstracts and Bibliography*, items 4.11–253 and 2.2–127, November 1953 and February 1951, respectively.)

"Tipy Pogody" or "Wettertypus" is "the weather of a day, which is characterized by established criteria: the values of the measured meteorological elements and the notes concerning the observations of the various atmospheric phenomena." Each type is a combination of all the pertinent elements, "every observed element in one type being taken within a certain interval of its scale."

In practice, complex climatology involves two steps. First, the observational record is classified into a large number of *types*, using "the smallest gradations and the largest number of elements possible." Then, for any specific problem, these rather detailed types are combined into a much smaller number of *groups*, "dispensing with some gradations and elements for a given purpose."

The weather types may refer to an instant, or to some time interval "of definite duration, preferably short." Federov used the day, "a natural unit of time." Weather elements considered in forming the types (with number of gradations in parentheses) were: wind direction and variation from night to day (26); wind force and variation (20+); mean daily temperature (20); temperature amplitude (8); interdiurnal temperature change (5); cloudiness by night and day (7); mean relative humidity (6); time of precipitation (3); amount of precipitation (10); and occurrence of showers, thunderstorms, and white frost (2 each). "In all, 16 elements for a season and 22 elements for all seasons are introduced."

No changes in the basic procedures of complex climatology, in the quarter century since this last exposition in English, are indicated in summaries of recent works by the authoritative Meteorological Abstracts and Bibliography. "A thorough exposition of the principles and methods of complex climatology as presented in previous articles and promulgated by E. E. Federov in 1921" was offered by Chubukov. The method was discussed anew by Fel'dman and Chubukov,[7] and used to define dry wind-drought weather, moderate drought weather, etc. It was explained and illustrated in a climatic textbook for hydrometeorologists.[8] The concepts of complex climatology were explained and defended at the October, 1954, meeting of the Hamburg branch of the German Meteorological Society by an East German colleague.[9]

Complex climatology has not taken very elaborate forms outside Russia. An attempt along lines similar to those developed independently by Federov was made by Howe, Switzer, and Nichols under the direction of C. F. Brooks.[10] More recent "statistical" climatology of this type has been restricted to combinations of two or, at most, three elements. Ceiling-visibility combinations have been tabulated by many agencies, and some geographical analysis of them has been attempted.[11] Temperature-wetbulb combinations were investigated by Allbright.[12] Frequency tabulations of combinations of hourly temperature with wetbulb depression and with wind speed at 117 stations, 1935–39, compiled by the Weather Bureau for the American Society of Heating and Ventilating (now Air Conditioning) Engineers, have been used for several studies,[13] but not as many as they deserve.

All these studies can be classified as complex climatology, as defined by Federov. His purely objective approach is concerned with simultaneous values of two or more weather elements, usually but not necessarily at a

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[7] IA. I. Fel'dman and L. A. Chubukov, "Klimat v pogodakh," *Priroda*, No. 10 (1953), pp. 42–48. (Reference from *Meteorological Abstracts and Bibliography*, item 5.11–190, November 1954.)

[8] S. I. Kostin and T. V. Pokrovskaia, *Klimatologiia* (Leningrad: Gidromet. Izdat., 1953), 426 pp. (Reference from *Meteorological Abstracts and Bibliography*, item 5.11–5, November 1954.)

[9] Erwin Pelzl, "Komplex-Klimatologie als witterungsklimatologische Untersuchungsmethode," *Annalen der Meteorologie*, Vol. 7 (1955/56), pp. 35–38.

[10] C. F. Brooks, ed., "Papers on the Relation of the Atmosphere to Human Comfort," *Monthly Weather Review*, Vol. 53 (1925), pp. 423–437. Includes: C. F. Brooks, "The Cooling of Man under Various Weather Conditions;" E. C. Donnelly, "Human Comfort as a Basis for Classifying Weather;" George F. Howe, "The Summer and Winter Weather of Selected Cities in North America;" E. S. Nichols, "A Classification of Weather Types;" J. Elmer Switzer, "Weather Types in the Climates of Mexico, the Canal Zone, and Cuba."

[11] Glenn Cunningham, "A Map of Flying Weather," *Annals*, Association of American Geographers, Vol. 42 (1952), pp. 247–250.

[12] J. C. Allbright, *Summer Weather Data* (Kansas City, Kan.: The Marley Co., 1939), 165 pp.

[13] Arnold Court, "Temperature Frequencies in the United States," *Journal of Meteorology*, Vol. 8 (1951), pp. 367–380.

single place. Complex climatology may be defined as:

> Analysis of the climate of a single place, or comparison of the climates of two or more places, by the relative frequencies of various "weather types" or groups of such types. Each weather type is defined by the simultaneous occurrence within specified narrow limits of each of several weather elements. In any given system of complex climatology, the element-limits for each type are fixed, as well as the time period to which the typing applies. Different systems use different element-limits, and even different elements, and may even use different periods.

Most of the "objective forecasting" procedures[14] developed in recent years are outside the field of complex climatology. Although they do involve the classifying of weather according to the simultaneous occurrence within given limits of various weather elements, these elements are not all at one place and time. Often they involve such things as pressure gradients, dew point "upstream" on some pressure surface, and precipitation at several places. Most of them are a form of synoptic climatology, to be discussed later.

DYNAMIC CLIMATOLOGY

Named, defined, and illustrated by Bergeron[15] at the 16th general meeting of the German Meteorological Society in Dresden on 7 Oct. 1929, *dynamic climatology* has become an important method of meteorological research and analysis—though frequently not called by this name.

"A revival of climatology can be obtained," Bergeron said, "by extending to all latitudes and climatic phenomena this consistent manner of thought," that is, of statistical treatment of stable weather types as complete phenomena or processes. "This kind of climatology may be designated as 'dynamic,' in analogy with dynamic meteorology. It could also be called 'synthetic,' since it treats the *totality* of phenomena instead of *individual* elements. . . ."

"To attain a dynamic climatology in the latitudes of the non-periodic weather changes, quasistationary weather types or forms must be 'dissected out'; these must be analyzable as well-defined, significant *total* systems or processes, analogous to the monsoons and trade winds of the zone of periodic or stable weather. Just as in the tropics, these apparently can be obtained by means of their characteristic flow components."

Dynamic climatology, Bergeron said, has two parts. First it "should describe the frequencies and intensities of well-defined systems, more or less self-contained dynamically and thermodynamically. . . . The second basis of dynamic climatology is the study of the formation and thermodynamical method of operation" of the fronts or principal frontal zones of the earth. Most of his paper was devoted to a detailed discussion of air mass properties and classification; a thermodynamic classification (cold or warm) was shown to be preferable to a geographic classification (arctic or tropic, continental or maritime) for the purposes of dynamic climatology.

"Such a dynamic climatology," wrote Willet[16] in the first American comment on Bergeron's paper, "is nothing other than the physical basis of long-range forecasting." Its aim is presentation of the several complete thermodynamic units controlling the climate of a region, rather than the unrelated distribution of the individual meteorological elements. . . . The fundamental problem of a dynamic climatology, which aims to present the underlying dynamic and thermodynamic phenomena of the atmosphere in their entirety, is to account completely for the mean activity of the centers of action."

In the proposal for a dynamic climatology, Chromow saw merely a restatement of the ideas advanced nearly a century earlier by Dove,[17] who considered weather processes in terms of continual conflict between southward-moving cold air and northward-moving warm

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[14] Irving I. Gringorten, "Methods of Objective Weather Forecasting," *Advances in Geophysics*, Vol. 2 (1955), pp. 57–92.

[15] Tor Bergeron, "Richtlinien einer dynamischen Klimatologie," *Meteorologische Zeitschrift*, Vol. 47 (1930), pp. 246–262.

[16] Hurd C. Willett, "Ground Plan of a Dynamic Climatology," *Monthly Weather Review*, Vol. 59 (1931), pp. 219–223. ("Meteorology" in title as originally published corrected, p. iv, to "Climatology.")

[17] S. Chromow, "'Dynamische Klimatologie' und Dove," *Zeitschrift für angewandte Meteorologie*, "*Das Wetter*," Vol. 48 (1931), pp. 312–314; Heinrich Wilhelm Dove, *Meteorologische Untersuchungen* (Berlin, 1837), 344 pp.

air. Korselt conceded a partial correspondence,[18] but emphasized that Dove did not consider the thermodynamic and hydrodynamic aspect of the various air masses, while such energy considerations were paramount in Bergeron's approach.

Bergeron's paper was entitled "Richtlinien einer dynamischen Klimatologie," which means the directions, orientations, or guide lines of a dynamic climatology. ("Outline," used in a rather poor translation issued, mimeographed, by the Weather Bureau around 1940, and "Outlines," used by Conrad and Pollak,[19] do not have quite the same connotation.) Two years later, Hesselberg published "procedures."[20] These, he said, and Bergeron's differed materially, but "attack the problem from different sides and complement each other."

"A *dynamic climatology*," said Hesselberg, "must be concerned with the quantitative application of the laws of hydrodynamics and thermodynamics to explain the average state and motion. The laws should be used to investigate the general circulation and state of the atmosphere, as well as the average state and motion for shorter time intervals (years, months, definite weather periods, etc.)." Hesselberg devoted his paper to establishing hydrodynamic and thermodynamic equations that are valid for such mean quantities.

Almost two decades later, Gião similarly defined dynamic climatology as "the branch of mathematical meteorology which aims at a deduction of the mean properties of the atmospheric perturbations that are compatible with a given mean field of temperature, wind, and pressure."[21]

Clearly, these originators of the term "dynamic climatology" considered it as the *climatology of atmospheric dynamics and thermodynamics*. They sought to describe the general circulation of the atmosphere in terms of its various characteristic situations, rather than in terms of monthly, seasonal, or annual means of pressure, temperature, wind, or precipitation. In fact, Bergeron declared that "studies of the average pressure distribution of a month and rainfall totals do not provide a dynamic climatology."

Bergeron proposed to build this dynamic climatology from the frequencies of air masses and frontal passages. Hesselberg developed modifications of the basic energy formulas of meteorology to handle time averages of the various elements; Gião extended this approach. Willett saw in Bergeron's dynamic climatology the basis for long-range forecasting. None of them considered the climate of a specific place, or even a region, except insofar as detailed local statistics, such as air-mass frequencies or pressure sequences, were useful in synthesizing the picture of the atmospheric *energy*.

Others, however, mistook the means for the end. Thus, Church told geographers that "dynamic climatology, in contrast to statistical climatology," offered information on the characteristics, frequencies, seasonal distributions, and deviations from these averages of distinct air masses.[22] The first actual example in the "search for a dynamic climatology" involved determination of mean temperatures for each of 20 "weather types" identified on the daily synoptic maps prepared in Hamburg 1919–24 and Berlin 1925–28;[23] they were primarily air masses, Thraen commented.[24]

The "dynamic study of climate," for which Cannellopoulos published an "introduction,"[25] concerned not the climate of atmospheric dynamics but rather something else, the dynamic effects of climate. He explained that "the dynamic study of climates could contribute to exhibiting in a more complete manner the influence exerted by the weather upon the de-

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[18] E. Korselt, "Noch einmal: 'Dynamische Klimatologie und Dove'," *Zeitschrift für angewandte Meteorologie*, "*Das Wetter*," Vol. 49 (1932), pp. 19–21.

[19] Victor Conrad and L. W. Pollak, *Methods in Climatology* (Cambridge, Mass.; Harvard Univ. Press, 1950), 459 pp. Reference to p. 316.

[20] Th. Hesselberg, "Arbeitsmethoden einer dynamischen Klimatologie," *Beiträge zur Physik der freien Atmosphäre*, Vol. 19 (1932), pp. 291–305.

[21] Antonio Gião, "A New Dynamical Climatology: Its Aim and Method," *Geofísica Pura e Applicata*, Vol. 15 (1949), pp. 114–129.

[22] Phil E. Church, "Dynamic Climatology," *Annals*, Association of American Geographers, Vol. 24 (1934), p. 45 (abstract).

[23] Else Nehls, "Das Klima des Ostseegebietes. Versuch einer dynamischen Klimatologie," *Jahrbuch der Pommerschen Geographischen Gesellschaft* (Greifswald), Vol. 51/52 (1934), pp. 3–90.

[24] Aug. Thraen, "Voraussetzungen einer dynamischen Klimatologie," *Petermanns [Geographische] Mitteilungen*, Vol. 81 (1935), pp. 167–168.

[25] George Cannellopoulos, *Introduction à l'étude dynamique du climat* (Athens, Hestia, 1936).

velopment of the animal and vegetal kingdoms."[26]

Similar approaches have dominated many studies containing in their titles the words "dynamic" and "climate." Thus Trojer's "Contribution to a Dynamic Climatology" developed a map-pattern classification for the statistical treatment of weather-events in the eastern Alps.[27] "Goal of 'dynamic' climatology as weather-climatology," he said, "is the treatment of the totality of all weather-occurrences over a given place." But the goal of the original dynamic climatology was to apply such treatment toward the hydrodynamic and thermodynamic explanation of the mean atmospheric circulation and its variations. The opposite approach, the description or explanation of local climates in terms of the large-scale circulation, taken in many studies, is the field of synoptic climatology.

SYNOPTIC CLIMATOLOGY

Wartime stresses may be blamed for the introduction of the term *synoptic climatology* without a clear-cut distinction from dynamic climatology. It was coined in 1942 by Jacobs.[28] With his colleagues in the A.A.F. Weather Service, he sought "a synoptic or synchronous climatology, that is, a method for breaking down the purely fictitious mean climatic picture into the actually-occurring weather patterns of which climate is composed." A footnote explained: " 'Synoptic' is used here with the meteorologist's connotation of 'simultaneous' or 'synchronous' rather than as defined by Webster meaning 'a general view' ".

This synoptic climatology was developed as "a convenient and practical way of cross-indexing historical synoptic weather information. . . . A knowledge of weather conditions as they would be expected to occur simultaneously over relatively large areas was required. Such weather relationships could have been determined each time a problem arose by the machine summary of large quantities of climatic data. But this required the expenditure of time, and . . . time was not available."

Thus a form of multiple complex climatology would have served the purpose best, but for lack of time a substitute was developed by mixing some synoptic meteorology with some dynamic climatology. The result was one of several possible ways of attaining a synoptic climatology.

A similar development occurred simultaneously in Great Britain, according to C. S. Durst of the Meteorological Office. In a welcome comment on the first draft of the present paper, he traced the development since the late 1920's, when M. A. Giblett, in charge of the meteorological unit for airship development, "was very enthusiastic in inculcating in us the idea of describing climate in synoptic terms." He started, and Durst and S. P. Peters continued, "a series of reports in which we were endeavoring to move from the climatology of the monthly normal to that of the synoptic classification."

During the war, British climatic studies came to include a section on the "synoptic climate," defined as "a classification of the types of weather experienced at the station or region and the frequency of their occurrence."[29]

"Synoptic climatology," Durst continued, "was a flower of slow growth. When it took shape is hard to say, but certainly it was developed in this country and in the United States under the demands imposed by the war. . . . What strikes me forcibly is how the method of writing climate from synoptic maps has so largely fallen into disuse since the war, despite the requests from I.C.A.O. and W.M.O. for such studies."

The British "synoptic climate" was somewhat more narrative and less numerical than the synoptic climatology of Jacobs. His use and discussion led to a definition of synoptic climatology as:

> Description and analysis of the totality of weather at a single place, or over a small area, in terms of the properties and motion of the atmosphere over and around the place or area.

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[26] George Cannellopoulos, "Contribution à l'étude dynamique du climat," *Comptes Rendus* (Paris), Vol. 202 (1936), pp. 150–151; also, same title, *La Météorologie*, Vol. 1937 (1937), pp. 117–126.

[27] Hans Trojer, "Ein Beitrag zu einer dynamischen Klimatologie," *Urania*, Vol. 34 (1949), pp. 112–139.

[28] Woodrow C. Jacobs, "Wartime Developments in Applied Climatology," *Meteorological Monographs*, Vol. 1, No. 1 (1947), 52 pp.; "Synoptic Climatology," *Bulletin of the American Meteorological Society*, Vol. 27 (1946), pp. 306–311.

[29] E. Gold, *Reports on the Meteorology of a Station or Area*, Meteorological Office, Synoptic Instruction No. 98, January 1943.

The relevant properties and motions are displayed, discussed, and described most conveniently by the synoptic weather map. In general, four different aspects of the weather map have been used in the development of synoptic climatology. The totality of weather conditions at a place, or over a small region, is related by:

air-flow climatology to the general direction of air movement (surface or aloft) over the place;

pressure-field climatology to the direction and distance to the nearest centers of high and low pressure, and their intensities and motions;

air-mass climatology to the frequencies and durations of the overlying air masses, classified by some standard system;

map-pattern climatology to the circulation type into which the synoptic weather map is classified, by some standard system.

The distinctions made by these terms, and the terms themselves (except for air-mass climatology) have not been used heretofore, so far as is known. They are introduced as convenient subdivisions of synoptic climatology, as just defined. Theoretically, the same subdivisions could be found in dynamic climatology, but they do not appear to have been used in that field and presumably would have little value. Hence they are applied here to synoptic climatology alone.

The "map patterns" of the fourth subdivision frequently are called "weather types,"[30] although Federov used the same term much earlier as the basis of complex climatology. Recently geographers have discussed "types of weather which repeat themselves"[31] and "weather types characteristic of various climatic regions."[32] Because of these diverse concepts for "weather type," the more descriptive term "map pattern" is used here for this branch of synoptic climatology.

Air-flow climatology is by far the oldest form of climatic analysis. Many peoples characterize the winds from various directions by the weather which they "bring," be it rain, heat, cold, or mosquitoes. Early in the 19th century, as soon as systematic weather observations had accumulated in sufficient quantity, the averages and frequencies of various weather elements, singly and in combinations, were computed for the winds of the eight points. The first wind rose diagram was not one of wind frequencies, but of the average barometric pressure associated with each wind direction.[33]

The leading German meteorologist of the middle 19th century, Dove, considered wind direction as the clue to all meteorological problems. For half a century wind roses of all sorts—baric, thermic, nephic, pluvic, etc.—were computed assiduously, fitted by Fourier series, and discussed at length.

Pressure-field climatology became possible when synoptic meteorology developed in the last half of the 19th century. Köppen grouped two years of morning observations at St. Petersburg into six classes, depending on the pressure distribution: whether the station was on an isobar which was straight, cyclonic, or anticyclonic, or was in the center of a low, high, or in an indeterminate situation.[34] Hildebrandsson studied the weather around cyclones and anticyclones, assumed to be radially symmetrical, by tabulating the daily weather for Uppsala according to the distance and direction from it to the high or low pressure center.[35]

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[30] H. H. Lamb, "Types and Spells of Weather Around the Year in the British Isles: Annual Trends, Seasonal Structure of the Year, Singularities," *Quarterly Journal of the Royal Meteorological Society*, Vol. 76 (1950), pp. 393–438.

[31] E. M. Frisby and F. H. W. Green, "Comparison of the Regional and Seasonal Frequency of Air Masses," *Comptes Rendus*, Congrès International de Géographie, Lisbonne, 1949, Vol. 2, pp. 307–314; F. H. W. Green, "A Few Notes on the Presentation of Regional Climatology," *Transactions of the Institution of British Geographers for 1947*, pp. 45—58; E. M. Frisby and F. H. W. Green, "Further Notes on Comparative Regional Climatology," *Transactions of the Institution of British Geographers for 1949*, pp. 141–151.

[32] Wesley Calef, "Weather Types as a Method of Analysis and Description of Climate," *Annals*, Association of American Geographers, Vol. 43 (1953), p. 160 (abstract).

[33] [Leopold] von Buch, "Ueber die Bewegungen des Barometers zu Berlin" and "Ueber barometrische Wind-Rosen." *Abhandlungen der königlichen Akademie der Wissenschaften in Berlin, 1818-1819* (1820), pp. 83–102, 103–110.

[34] Wladimir Köppen, "Über die Abhängigkeit des klimatischen Charakters der Winde von ihrem Ursprunge," *Reportorium für Meteorologie*, Vol. 4, No. 4 (1874), 15 pp.

[35] H. H. Hildebrandsson, "Sur la distribution des éléments météorologiques autour des minima et des maxima barométriques," *Nova Acta Regiae Societatis Scientiarium Upsaliensis*, series 3, Vol. 12, No. 6 (1883), 31 pp.

Ward urged climatic analysis in terms of "cyclone units."[36] Henry lamented that "it would also be a great help to the better understanding of seasonal variations in the weather if the usual statistics of temperature and rainfall distribution, amount of cloudiness, etc., were classified and arranged according to the several types of weather that prevail in the United States."[37] Although these types were simply cyclonic and anticyclonic, Leighly indicated that Henry "could not give his presentation the form he desired, but he did what he could . . . by describing in synoptic terms and by illustrative weather maps the synoptic situations that are responsible for spells of typical and atypical weather. . . . Henry's appeal for a synoptic climatology had no perceptible effect."[38]

Air-mass concepts were applied to climatic analyses even before Bergeron's persuasive outline of their suitability for dynamic climatology. Geiger studied the detailed air mass characteristics causing a spotty thunderstorm pattern in southwest Germany on 16 May 1926.[39] In the first paper to be entitled "air mass climatology," Dinies tabulated the frequency of occurrence, and average temperature, of each of eight air masses at Frankfurt.[40]

An extensive literature has developed in air-mass climatology, despite the impossibility of any objective, unequivocal scheme of air-mass classification. An excellent survey of its development and potentialities has been given by Durst without, however, using any specific name.[41] His arguments in favor of air-mass climatology are chiefly that it provides an "explanation of climate as a physical and dynamic phenomenon." Another eminent British climatologist recently rejoiced that meteorology is returning from mathematical dynamics to the more basic concepts of air masses and trajectories; "the essence of air mass climatology is that the wind brings the weather."[42]

Most applications of air-mass and air-flow climatology have been meteorological, emphasizing the properties and modifications of the air masses rather than the local weather that they cause. Others are largely geographical, explaining regional climates in terms of air masses and general directions of flow. Relatively few papers have applied such methods to the United States.[43]

Map-pattern climatology relates surface weather conditions within an area to the general pressure and flow patterns over a much larger region. This change in scale is a major difference between it and the other subdivisions of synoptic climatology, which do not consider conditions much beyond the boundary of the area of interest.

The general flow patterns are classified into many types for each region. In the most detailed and most used classification of this sort, the region is nearly one quarter of the northern hemisphere, corresponding to the domain of one of the major troughs or ridges of the upper level hemispheric circulation. This system,

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[36] Robert de C. Ward, "Suggestions Concerning a More Rational Treatment of Climatology," *Report of the 8th International Geographical Congress*, 58th Cong., 3rd Sess., House Doc. 460 (Washington, 1904), pp. 277–293.

[37] Alfred Judson Henry, *Climatology of the United States*. U.S. Weather Bureau, Bulletin Q, 1906, 1012 pp. Reference to p. 81.

[38] John Leighly, "Climatology," Chap. 14, pp. 335–361, of *American Geography, Inventory and Prospect* (Syracuse University Press for Association of American Geographers, 1954), p. 343.

[39] Rudolf Geiger, "Beispiel eines Luftkörperkampfes in seiner Abhängigkeit von der Geländergestaltung," *Beiträge zur Physik der freien Atmosphäre*, Vol. 16 (1929), pp. 57–75.

[40] Erwin Dinies, "Luftkörper-Klimatologie," *Aus dem Archiv der deutschen Seewarte*, Vol. 50, No. 6 (1932), 21 pp.

[41] C. S. Durst, "Climate—the Synthesis of Weather," *Compendium of Meteorology* (Boston: American Meteorological Society, 1951), pp. 967–975.

[42] A. Austin Miller, "Air Mass Climatology," *Geography*, Vol. 38 (1953), pp. 55–67.

[43] H. Landsberg, "Airmass Climate for Central Pennsylvania," *Gerlands Beiträge zür Geophysik*, Vol. 51 (1937), pp. 278–285; Arch C. Gerlach, "Distribution of Air-mass Types and Frequency of Change in the Western United States during 1937–38," *Monthly Weather Review*, Vol. 66 (1938), pp. 376–377; John R. Borchert, "The Climate of the Central North American Grassland," *Annals*, Association of American Geographers, Vol. 40 (1950), pp. 1–39; "Regional Differences in the World Atmospheric Circulation," *Ibid.*, Vol. 43 (1953), pp. 14–26; Photios P. Karapiperis, "The Climate of Blue Hill According to Air Masses and Winds," *Harvard Meteorological Studies*, No. 9 (1951), 105 pp.; Dieter H. Brunnschweiler, "Geographic Distribution of Air Masses in North America," *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich*, Vol. 97 (1952), pp. 42–49; "Toward a Classification of Climates on an Aerosomatic Basis," *Annals*, Association of American Geographers, Vol. 45 (1955), p. 172 (abstract).

developed over a quarter-century by Baur,[44] recognizes at least 25 kinds of "Grosswetterlagen" for Europe (they form 17 major types, the rest being subtypes), and 16 for the North Atlantic.

In the system of "three-day" weather patterns originated by Krick and refined by Elliott,[45] the corresponding regions are only half as large, covering 45° of longitude; for each region some 20 or 30 different "types" or patterns are used. For each system, tabulations have been made of the weather to be expected from each "type"; the Krick-Elliott tabulation was for departures of average temperature and pressure from "normal."

Each system has been used for studies in synoptic climatology. Each day's northern hemisphere synoptic map since 1899 has been typed in the Krick-Elliott system for North America, and also for the North Atlantic and Europe. The European catalog, prepared by International Meteorological Consultant Services of London, used 22 basic types, distinguished by color: red for zonal, green for meridional, blue for mixed.

The Baur catalog is even longer. Each day since 1881 has been assigned to one of the standard "types" for western and central Europe, so that studies for various places can have a common basis.[46] This catalog has been used for various forms of synoptic climatology.[47]

Synthesis of all four of these methods was attained in the development of what Jacobs called "synoptic climatology." The "purely objective form of map classification—one made on the basis of air flow at the gradient level"—involved classifying each daily weather map, for each "homogeneous" area of something like 100,000 square miles, according to

a. direction of gradient flow over area;
b. gradient wind speed;
c. curvature of isobars over area (cyclonic or anticyclonic);
d. air mass type over area.

For each map so classified, all weather data for each station in the area were summarized "with respect to flow type, speed of flow, character of flow, and air mass type." The resulting frequency tables for each element or group of elements, for each station, were then used for detailed planning of military operations, chiefly aerial. In the final years of World War II, several studies were prepared by this standardized procedure, but no subsequent examples of its use have been published. Apparently, with some time available for such studies, the needed information can be obtained by machine summarization in the form of multiple complex climatology; an air route study by two of Jacobs' assistants is of this type, although entitled "synoptic-climatological."[48]

Objective forecasting is "the use of the synoptic-climatic method for weather forecasting,"[49] but properly this applies only to methods with a physical basis or rationale. Another class of objective methods, as emphasized in Gringorten's able review, is purely empirical. It uses numerical rather than physical relationships between predictors and predictand.

The distinction between physical objective forecasting and synoptic climatology seems to be disappearing. At one time a weather forecast was a more or less definite statement of the sequence of weather expected to occur dur-

[44] Franz Baur, "Extended-range Weather Forecasting," *Compendium of Meteorology* (Boston: American Meteorological Society, 1951), pp. 814–833.

[45] Robert D. Elliott, "Extended-range Forecasting by Weather Types," *Compendium of Meteorology* (Boston: American Meteorological Society, 1951), pp. 834–840.

[46] Paul Hess and Helmuth Brezowsky, "Katalog der Grosswetterlagen Europas," *Berichte des Deutschen Wetterdienstes in der U. S. Zone*, No. 33 (1952), 39 pp.

[47] K. Bürger, "Über die Temperaturen der Grosswetterlagen," *Berichte des Deutschen Wetterdienstes in der U. S. Zone*, No. 42 (1952), pp. 146–154; Irma Bleibaum, "Studien zur Meteorologie der südlichen Rhön," *Berichte des Deutschen Wetterdienstes*, Vol. 1, No. 4 (1953), 15 pp.; M. Bider, "Statistische Untersuchungen über die Hagelhäufigkeit in der Schweiz und ihre Beziehungen zur Grosswetterlage," *Archiv für Meteorologie, Geophysik, und Bioklimatologie*, Serie B, Vol. 6 (1954), pp. 66–90; O. Essenwanger, "Zur Häufigkeitsanalyse von Grosswetterlagen," *Meteorologische Rundschau*, Vol. 8 (1955), pp. 55–56; Hans Maede, "Die Regenwetterlagen an der südlichen Ostseeküste," *Abhandlungen*, Meteorologischer und Hydrologischer Dienst, Deutsche Demokratische Republik, No. 30 (1954), 121 pp., also in *Zeitschrift für Meteorologie*, Vol. 7 (1953), pp. 48–57, 65–73, 117–123, 129–146.

[48] N. W. Manos and W. L. Molo, "A Technique for a Synoptic-Climatological Study of an Air Route," *Bulletin of the American Meteorological Society*, Vol. 29 (1948), pp. 401–407.

[49] Helmut E. Landsberg and Woodrow C. Jacobs, "Applied Climatology," *Compendium of Meteorology* (Boston: American Meteorological Society, 1951), pp. 976–992.

ing a coming period of hours, days, or even weeks or months. Now most forecasts for more than a day or two deal only with the departures of conditions from average, and even some short-term objective forecasts are estimates of the probabilities of various weather events rather than predictions of an exact sequence. These forecasting procedures are indeed applied synoptic climatology if they are based on physical and dynamic relationships between the general state and motion of the atmosphere and the ensuing weather events.

Empirical objective forecasting, however, is not a part of synoptic climatology. Perhaps it is a part of an "empirical climatology," which finds statistical relationships between different sets of weather events, without their explanation or justification. Meteorological literature abounds with examples of empirical "tele-connections"; a few subsequently have been shown to have physical basis, others are unexplained, but many turn out to be fortuitous and not significant when additional observations are considered.

Synoptic climatology is acclaimed by its advocates as explaining the climate, as making climatology alive and "dynamic"—in the nontechnical sense. Its purpose, therefore, is something more than "to specify, for a given state of the atmospheric circulation, the probability of occurrence of values of a climatic element at a point in the region," as Friedman declared.[50] His empirical objective forecasting procedure predicts morning temperatures and 24-hour precipitation from a 16-term linear combination of orthogonal polynomials. These polynomials are claimed to represent the pressure pattern over the United States and Southern Canada "to a satisfactory degree," but no details are given; the method, developed by Wadsworth, was presented eight years ago in a military report not available to the public.

While Friedman's equations may be an effective forecasting tool (they were not presented in sufficient detail for independent evaluation), they certainly do not *explain* the local weather or climate. Their only physical basis is that weather must be dependent on the pressure field somehow, but just how is hidden inside a digital computer. The corresponding "empirical influence functions" of a closely parallel study,[51] published simultaneously, admittedly may not have physical interpretation.

Despite Friedman's intention of "basing a synoptic climatology on the broader-scale features of the atmospheric circulation," he has instead based an empirical climatology on mathematical manipulation rather than physical features. Perhaps his empirical regression functions will lead to discovery of new physical relations and principles, as Hare and T. F. Malone (private discussion) believe. At present, however, they hardly provide the synoptic climatology sought by von Buch, Dove, Köppen, Hildebrandsson, Ward, Henry, and others, named by Jacobs and Gold, and advocated by Durst, Miller, Leighly, Hare and many, many more.

DISTINCTIONS

In introducing a new term, Jacobs did not distinguish between his synoptic or synchronous climatology and Bergeron's established dynamic or synthetic climatology; nor, for that matter, did he cite any related discussions. Only two serious efforts to differentiate between synoptic and dynamic climatology seem to have been made.

F. Kenneth Hare, a wartime military climatologist in England who is now chairman of the Department of Geography at McGill University, until recently considered the two terms as synonymous. Once he explained dynamic climatology as "the explanatory description of climate in terms of air-mass and frontal phenomena, the movement of depressions and anticyclones or, in short, in terms of the general atmospheric circulation of the region. . . . The dynamic climatologist seeks . . . to render description vivid and comprehensive by basing it upon a dynamic analysis of the processes involved. Recent American writers have sometimes used the term 'synoptic climatology' for the same subject."[52]

A few years later, his lively and excellent book defined dynamic climatology as "the explanatory description of climates in terms of

[50] Don G. Friedman, "Specification of Temperature and Precipitation in Terms of Circulation Patterns," *Journal of Meteorology*, Vol. 12 (1955), pp. 428–435.

[51] Robert M. White and William C. Palson, Jr., "On the Forecasting Possibilities of Empirical Influence Functions," *Journal of Meteorology*, Vol. 12 (1955), pp. 478–485.

[52] F. Kenneth Hare, "Dynamic Climatology in Geographic Studies," *Revue Canadienne de Géographie*, Vol. 2 (1948), pp. 9–16.

the circulation or disturbances of the atmosphere."[53] Elsewhere he referred to "dynamic climatology, where the ideas of the modern weather analyst are put to good use in explaining regional climates."

A couple of years later he declared "The term dynamic climatology was coined, 20 years ago, by Tor Bergeron to denote the explanation of climate according to the effects of atmospheric circulation. In recent years more and more emphasis has been placed on the explanation of world climates in these terms . . ."[54]

More recently, in discussing "some of the methods whereby the climatological record is being put into a shape more valuable to the meteorologist and the regional geographer," Hare distinguished between "dynamic and synoptic climatology, closely related and rapidly developing fields. . . . The former is broader in scale, being in effect a regional or global synthesis of daily circulation types. Synoptic climatology, on the other hand, deals specifically with regions small enough for the recognized circulation types to be interpreted in terms of the ordinary weather elements. The former was conceived intellectually as a method of illuminating the study of world climates; the latter came into being as an empirical method of meeting operational needs."[55]

The second attempt at a distinction was by the "Working Group for Dynamic Climatology" established by Resolution 4 of the W.M.O. Commission on Climatology at Washington, D.C., during March of 1953. It was "to survey . . . the field of dynamic climatology." To define the scope of its task, the chairman drafted an article which, after revision and approval by the group, proposed three definitions of dynamic climatology, as:

"the climatology of dynamic meteorology.

"the study and analysis of knowledge derived from the treatment, by statistical methods, of populations of quantities, observed or computed, in the field of dynamic meteorology;" these quantities included velocity, momentum, energy, convergence, divergence, and vorticity.

"the dynamic or physical interpretation or explanation of the contemporary climatic patterns and the changes of shorter or longer period which take place in these patterns."[56]

Comments aroused by the article, and further deliberations by the Working Group, were incorporated into the chairman's report (dated 1 May 1954, mimeographed; summarized in an annual report).[57] It indicates that some members thought "it may be difficult and undesirable at this stage to draw a rigid line of demarcation between these two branches of climatology," dynamic and synoptic. Among the uses of dynamic climatology listed were long-range forecasting and a classification of climates "to make climatic patterns intelligible in terms of dynamic weather activity rather than plant life," which the present discussion indicates to be more properly the field of synoptic climatology.

The final definition of dynamic climatology (according to a personal letter dated 10 September 1955 from Mr. Gordon) was revised slightly and

forwarded to the W.M.O. Secretariat for official inclusion in the Universal Decimal Classification. This reads as follows:

Dynamic Climatology is the statistical collation and study of observed elements or derived parameters of the atmosphere, particularly in relation to the physical and dynamical explanation or interpretation, either of the contemporary climate patterns with their anomalous fluctuations or of the long-term climate changes and trends.

By specifying dynamical explanation as a major but not exclusive purpose, this definition obscures the basic distinction between *dynamic, synoptic, complex,* and even *"empirical"* climatology. Complex climatology is also the "statistical collation of observed elements" by themselves, usually for a single place. "Empirical" climatology is the "statistical collation of observed elements or derived parameters of the atmosphere," when it is specifically the collation of observed elements at one place with

[53] Hare, *"The Restless Atmosphere"* (London: Hutchinson's University Library, 1953), 192 pp.

[54] Hare, "Weather and Climate," Chap. 4, pp. 58–83, of *"Geography of the Northlands,"* George H. T. Kimble and Dorothy Good, eds., American Geographical Society Special Publication No. 32 (New York: Wiley, 1954), 534 pp. References to pp. 58–59.

[55] Hare, "Dynamic and Synoptic Climatology," *Annals,* Association of American Geographers, Vol. 45 (1955), pp. 152–162.

[56] A. H. Gordon, "Dynamic Climatology," *W.M.O. Bulletin,* Vol. 2 (1953), pp. 121–124.

[57] W(orld) M(eteorological) O(rganization), *Annual Report,* 1954. W.M.O. No. 41, RP. 18. Reference to sec. 6.3.18.

derived parameters at another, without physical or dynamical explanation. Synoptic climatology is "statistical collation of observed elements" as related to "the contemporary climate patterns" of the atmosphere.

One important distinction to be made is in the direction of the relationship sought by the "collation": dynamic climatology generalizes from local observations to the energy processes of the entire atmosphere, while synoptic climatology particularizes from the atmospheric circulation to local weather.

In correspondence in which he concurred in the distinctions drawn in the present paper, Mr. Gordon recalled his earlier definition: "Dynamic climatology refers to the study of the application of climatological data to large-scale dynamical problems involving the general circulation of the atmosphere."[58]

He felt that "I did, in fact, originally see the light of true dynamic climatology and recognized its essential premises; but . . . later lost the way, partly perhaps in an attempt to find a compromise solution on behalf of the advocates of both dynamic and synoptic climatology."

Many other meteorologists, climatologists, and geographers have been similarly confused. Much of the confusion comes from considering only method, and not purpose.

CONCLUSION

Purpose and use are the best criteria for distinguishing the various forms of modern climatic analysis.

Complex climatology is the preferred form of analysis and presentation of climatic information for practical applications. It is intended for the military planner, agriculturist, designing engineer, vacationer, or sales manager. It presents the observed frequencies of those specific combinations of weather conditions which are important to the problem at hand. These combinations must be selected from consideration of the problem, and differ from one problem to the next, from aircraft operations to tomato cultivation, from air-conditioning to golfing.

Dynamic climatology is essentially for the research meteorologist. It describes and explains the atmospheric circulation over a large part, if not all, of the earth, in terms of the available sources and transformations of energy. For this description and explanation, a description of the totality of weather is needed for each of the several homogeneous areas of the large region under consideration. This smaller-scale description is obtained most conveniently in terms of air-mass characteristics, frequencies, and successions—but studies of these properties do not, of themselves, constitute dynamic climatology.

Synoptic climatology is, in most cases, for the climatologist himself, and for the physical geographer and the forecasting meteorologist. It describes the totality of weather resulting from, or at least physically related to, some aspect of the atmospheric circulation, as conveniently portrayed on a synoptic weather map. It is the essence of an "explanatory-descriptive" system of climatology, providing "understanding of cause and effect" and "the possibility of predicting phenomena from limited information," as Strahler put it.[59]

Thus synoptic climatology may supplement the tabulations of complex climatology, or even be used to provide estimated frequencies of weather conditions for a place without adequate observations. Likewise, the tabulations of complex climatology may be used in the computations of dynamic climatology, as when the progress of anticyclogenesis is studied in terms of the frequencies of periods of clear sky with little wind.

Despite these many combined uses, the distinctions between the three procedures are real and valid. Dr. Helmut Landsberg, Director of the Weather Bureau's Office of Climatology, in commenting on the earlier draft of this paper, admitted he had "found it very difficult to give the term dynamic climatology a precise meaning." He felt it was generally the opposite of "static climatology," and thus he "would particularly include the areas of air mass climatology and synoptic climatology as a subdivision of dynamic climatology."

Certainly this view is shared by others, as has been indicated at the end of the discussion of dynamic climatology. But it was not the

[58] A. H. Gordon, "Development of Modern Technique in Marine Meteorology," *Meteorological Magazine*, Vol. 80 (1951), pp. 78–83.

[59] Arthur N. Strahler, "Empirical and Explanatory Methods in Physical Geography," *The Professional Geographer*, Vol. 6 (1954), pp. 4–8.

concept of the originators of dynamic climatology, and the developments of the ensuing quarter-century have indicated two distinct forms of climatic investigation. Perhaps the historical discussion presented here has helped to clarify these distinctions, and to formulate better definitions and understanding of complex, dynamic, and synoptic climatology.

THE SPATIAL STRUCTURE OF AGRICULTURAL ACTIVITIES[1]

WILLIAM L. GARRISON AND DUANE F. MARBLE
University of Washington

MEMBERS of the geographic profession have long been concerned with the spatial structure of human activities and have produced an extensive body of literature dealing with agriculture in general.[2] These geographic studies of the spatial structure of agriculture have made a significant number of concepts available to the research worker, but nowhere does there appear any explicit proof of one of the basic theorems, namely: that for every spatial location there is some jointly optimum intensity of land use, type of land use, and group of markets, the selection of which by the agricultural entrepreneur leads to spatially ordered patterns of land use.

This paper presents rigorous examinations of proofs of the existence theorem stated above. The establishment of a rigorous proof of this theorem provides an important link in the development of concepts pertaining to the spatial structure of agriculture.

The establishment of a rigorous proof of the existence theorem provides a second important contribution by spelling out the context of information and concepts within which the theorem holds. The context within which the theorem may be proved provides a guide to those variables pertinent to taxonomic and process oriented studies of agricultural areas.[3]

STATEMENT OF THE PROBLEM

Each entrepreneur engaged in agricultural operations must make a series of decisions over time involving several complex elements. The farm operator must decide, in reference to his particular location, (a) what crop or crop combination should be grown, (b) how intensively the chosen crop mix should be cultivated (i.e., what level of capital and labor inputs should be chosen), and (c) at what market or group of markets the resultant production should be sold.[4] It is assumed here that the entrepreneur makes that decision which will permit him to maximize his net return (i.e., rent); the solution which permits the most efficient attainment of this goal will be defined here as the *optimum solution*. The proof of its existence is the subject of the following study.

The techniques utilized, for the most part set theory, axiomatic structures, and differential calculus, were selected because they have proved to be the most efficient analytical tools available for theoretical maximization problems of this general nature.[5]

[1] We are especially indebted to Dr. Patrick Suppes of the Institute for Advanced Study in the Behavioral Sciences for his assistance to Mr. Marble in a preliminary formulation of the proof of the linear case presented in this paper. Others who have given valuable assistance are Dr. Joseph D. Phillips of Idaho State College, Mr. Gustav Ranis of Yale University, Mr. Robert Wright of the Boeing Airplane Company, Dr. M. E. Marts of the University of Washington, and Dr. Richard B. Maffei of the Massachusetts Institute of Technology. Many persons also contributed by commenting on a paper, "The Effect on Agriculture of Changes in Transportation," unpublished manuscript read by W. L. Garrison at the 1954 meetings of the Association of Pacific Coast Geographers and by commenting on a study by Duane F. Marble, "The Spatial Structure of the Farm Business" (unpublished M.A. thesis, Department of Geography, University of Washington, 1956).

[2] Extensive bibliographies relating to geographic studies of agriculture may be found in: Harold H. McCarty, "Agricultural Geography," in P. E. James and C. F. Jones, eds., *American Geography: Inventory and Prospect* (Syracuse University Press, 1954).

[3] An existence theorem does just what is implied by the term. In the present case, proof of the existence theorem would show that a spatial structure may exist and this is the premise on which many presently available studies are based. The role of existence theorems in research is stated in E. Bright Wilson, Jr., *An Introduction to Scientific Research* (New York: McGraw-Hill, 1952), pp. 306–307.

[4] An important approach to these decisions is given by Bernard Bowlen and Earl O. Heady, *Optimum Combinations of Crops at Particular Locations*, Iowa State College Experiment Station, Bull. 426, 1955. A statement of the farmer's decision problems may be found in William L. Garrison's *The Benefits of Rural Roads to Rural Property* (Seattle: Washington State Council for Highway Research, 1956), p. 96.

[5] An introduction to most of the tools used in the ensuing discussion is available in W. L. Duren, Jr., *et al., Universal Mathematics, Part II: Structures in Sets* (New Orleans: Tulane University Book Store, 1955). Axiomatic methods have been discussed by Hans Netterberg, "On Axiomatic Theories in Sociology," in Paul F. Lazarsfeld and Morris Rosenberg, eds., *The Language of Social Research* (Glencoe: The Free Press, 1955), pp. 533–540.

GENERAL BACKGROUND

While it is not a function of this study to review all the theories relating to agricultural location, some brief comments upon those from which the general conceptual scheme has arisen will serve to orient the following analysis.

Some two hundred years ago an Italian, Giovanni Vico, put forth the then radical idea that human society was not just a random collection of rather remarkable happenings, but was in actuality an ordered and lawful structure.[6] Over a hundred years passed before this concept was extended to the examination of the spatial organization of human activities.

The first writer to make space an explicit dimension of a theoretical structure of agriculture was a German, Johann Heinrich von Thünen.[7] In his model the rent (i.e., net profit) derived from any particular agricultural land use is a function of the linear distance from a central market. Different land uses have different rent-distance relationships and hence, at any given point in space, differing abilities to bid for the available land. The basic notion is that the form of agricultural land use which produces the greatest rent will make the highest bid for the land and thus displace all other uses. Thünen concluded from this that, under the limiting assumptions implicit in his model, a series of belts or rings of different agricultural land uses would form around the single central market, with the intensity of cultivation decreasing with increasing distance from the market.

While the theoretical system proposed by Thünen represented a great advance over any previous work, in certain respects it was quite crude and unarticulated. Several authors attempted to develop the spatial aspects of this model further, but their work contributed to the clarification of certain minor points rather than to producing any significant advances in basic theory.[8]

Recently, an American, Edgar S. Dunn, Jr., proposed an equilibrium system for the agricultural segment of the economy in which space was considered as an explicit variable.[9] The equilibrium system is largely non-operational; however, the remainder of his work provides what is perhaps the most complete development of a Thünen type system available today. Dunn discusses the effect of relaxing certain of Thünen's original limiting assumptions, but in a non-rigorous manner. Upon completion of his study he concludes that when the limiting restrictions are relaxed:

> The simplicity of land-use patterns is destroyed once and for all. However, this does not mean that order and system are destroyed. It means that the order imposed by the economic influence of distance takes on increasingly complex forms . . . [and] although its mathematical expression becomes more complex, such a solution remains within the limits of the tool.[10]

Other recent work in the United States has shown the close relationship between industrial location theory and agricultural location theory.[11] Isard pointed out one minor difference: that is, industrial location theory deals mainly with one and only one product, while a set of products must be considered in agricultural location theory.[12] It might

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[6] Giovanni Vico, *Principles of a New Science Dealing with the Nature of Nations . . .*, cited in Edmund Wilson, *To the Finland Station* (New York: Harcourt-Brace and Co., 1940).

[7] J. H. von Thünen, *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*, translated in part in W. K. Kapp and L. L. Kapp, eds., *Readings in Economics* (New York: Barnes and Noble, 1949). See also Richard Krzymowski, "Graphic Presentation of Thünen's Theory of Intensity," *Journal of Farm Economics*, Vol. 10 (1928), pp. 461–482.

[8] Explicit recognition of the spatial aspects of the von Thünen model is made in August Lösch, *The Economics of Location*, translated by W. H. Woglom and W. F. Stolper (New Haven: Yale University Press, 1954); E. T. Benedict, H. Stippler, and M. R. Benedict, *Theodor Brinkmann's Economics of the Farm Business* (Berkeley: University of California Press, 1935); and Edgar S. Dunn, Jr., "The Equilibrium of Land-Use Patterns in Agriculture," doctoral dissertation, Harvard University, 1952, published as *The Location of Agricultural Production* (Gainesville: University of Florida Press, 1955). Other aspects of von Thünen's model are treated by Arthur H. Leigh, "Von Thünen's Theory of Distribution and the Advent of Marginal Analysis," *Journal of Political Economy*, Vol. 54 (1946), pp. 481–502.

[9] *The Location of Agricultural Production*, *op. cit.*

[10] *Ibid.*, pp. 92–93.

[11] *Ibid.*, pp. 86–92, and Walter Isard, "Distance Inputs and the Space Economy: Part I: The Conceptual Framework," *Quarterly Journal of Economics*, Vol. 62 (1951), pp. 181–198.

[12] Walter Isard, "A General Location Principle of an Optimum Space-Economy," *Econometrica*, Vol. 20 (1952), pp. 406–430.

also be added here that the costs of transporting raw materials, which are so important in industrial location, are usually equated to zero in theories dealing with agricultural location.[13]

FORMULATION OF THE MODEL

Essential to the rigorous development of any theory relating to the real world is the construction of a model or analogue of that portion of the real world under investigation. Through operations on this model the research worker is able to attempt investigations whose nature would render them extremely difficult without the aid of this convenient abstraction. In this section a logical model of the farm business is constructed utilizing the devices of axiomatic structures and set theory.

Construction Techniques

The use of an axiomatic structure provides what is perhaps the most satisfactory form of model. Construction here in the axiomatic form follows common practice, namely:

(A) *A priori* assumptions from other theories and disciplines are explicitly stated. While the research worker is committed at all times to use clear, well-defined models, there is no concomitant commitment on his part to start from the beginnings of the discipline.

(B) The primitive notions of the theory are set forth. These notions represent certain ideas which must remain undefined in the model, but about which the researcher has sharp intuitive ideas. (The notion of *space* in geographic thinking might be put forth as a simple example.)

(C) The individual axioms are formulated using only the primitive notions and notions from the theories assumed under (A) above. In general, the axioms are chosen so that they do not contradict what is known to be true, and so that they are consistent and independent.

(D) Theorems (i.e., statements which are logical consequences of the axiom system) are stated and rigorous proofs put forth.

Models constructed in this manner have been found to have many virtues. For example, the axiomatic structure permits the user readily to make the distinction between statements which define terms and those statements which merely specify relationships between things which are independently defined. While the technique of forcing the reader to decide just how certain statements are intended is sometimes useful as a pedagogical device, its utilization in theory development is highly questionable.[14] The axiomatic form also provides the researcher with a means of locating strategic research problems. At any state of development of the model it should always be clear just which portions of the theory are proved and which parts are still unverified. The user of the model is also presented with a limited area in which he can locate the source of the failure of a particular hypothesis to meet empirical tests. While many other advantages may be claimed for the axiomatic form, it is felt that these few examples well illustrate its usefulness.[15]

Limiting Assumptions

Most previous studies of the spatial aspects of agriculture have included, either implicitly or explicitly, three major limiting assumptions:

(A) That a state of perfect competition exists within the system: that is, the individual entrepreneur is unable to influence either the level of prices received or the level of prices paid because of the relatively small size of his operation and the large number of competing operators.

(B) That the farm operator makes his decisions in the light of complete information: that is, he is at all times completely informed regarding the physical and economic characteristics of the situation in which he moves.

(C) That the geographic area upon which all farm operations take place is an unbounded plain of uniform fertility, and with a transport

[13] An interesting exception to this statement is provided by the inner ring of Thünen's original model. The outer boundary of this ring is defined as being at a distance from the central market such that the shipment of manure from the town to the farm is no longer economically feasible.

[14] An excellent example of an attempt to examine a famous classical theory in the light of modern concepts of theory construction may be found in Kingsley Davis, "Malthus and the Theory of Population," in Lazarsfeld and Rosenberg, *op. cit.*, pp. 540–553.

[15] A more extended discussion of these and other points may be found in Netterberg, *op. cit.*

system which permits every point on the plain to have direct and unlimited access to a single central market place.

The first two limiting assumptions will be retained in the model to be constructed here, but the third will be drastically modified. It is assumed here that the farm operator must consider not one, but a large set of markets, and that variations in fertility from one location to another may be allowed for by associating with each farm unit and crop a yield function which, in the light of the particular fertility conditions existing at that location, reflects the quantitative relationship existing between intensity of cultivation and resultant yield. All distances in the model are considered to be measured over the most direct routing of a transport system which may, and in most cases does, discriminate between locations. This modification is possible because the present analysis is directed toward the individual farm business rather than toward an aggregative or industry level solution.

Since the objective is to construct a system of abstractions which corresponds in some meaningful way to a certain aspect of the real world (i.e., the farm business), any modification of the limiting assumptions in the direction of greater correspondence with reality may be considered desirable. Since the modified third assumption seems to present a more accurate picture of the real world than the unmodified case, it is possible to conclude that the limiting assumptions of the present study are to some unknown extent "better" than those of previous studies.

Definitions and Primitive Notions

Definitions

R^* —the set of all positive real numbers

R^{**}—the set of all non-negative numbers

Primitive notions

C—a finite set of crops

M—a finite set of markets

d —a real valued function defined on M; $d(m)$ is the distance of market m from the farm unit

y —a function defined on $C \times R^*$; for $c \in C$ and $x \in R^*$, $y(c, x)$ is the yield of crop c when x units of "at-site" inputs (i.e., capital and labor) are employed in the production of the crop

a —a function defined on $C \times R^*$; for $c \in C$ and $x \in R^*$, $a(c, x)$ is the production cost of one unit of crop c when x units of at-site inputs are directly employed by the farm operator

p —a function defined on $C \times M$; for $c \in C$ and $m \in M$, $p(c, m)$ is the price of one unit of crop c delivered at market m

t —a function defined on $C \times R^{**}$; for $c \in C$ and $d(m) \in R^{**}$, $t(c, d[m])$ is the cost of transporting one unit of crop c one mile when the producing farm unit is $d(m)$ miles from the market.

Axiom System

Upon the basis of the above notions, the following definition is made: A system $<C, M, d, y, a, p, t>$ is a *simple optimal location system* if and only if the second derivative of all functions exists and the following axioms hold:

A1 for every $c \in C$, and $m \in M$, $p(c,m) \geq 0$

A2 for every $m \in M$, $d(m) \geq 0$

A3 for every $c \in C$, and $x \in R^*$, $y(c,x) \geq 0$

A4 for every $c \in C$, and $x \in R^*$, $a(c,x) \geq 0$

A5 for every $c \in C$, and $d(m) \geq 0$, $t(c,d[m]) \geq 0$

The preceding five axioms serve to exclude the possibility of negative prices, distances, yields, and costs appearing in the system. It is also necessary to describe explicitly the form of the various functions (Fig. 1).

A6 for every $c \in C$, $y(c)$ is strictly increasing

A7 for every $c \in C$, $y'(c)$ is a constant function

A8 for every $c \in C$, $a(c)$ is strictly increasing

A9 for every $c \in C$, $a'(c)$ is a constant function

A10 for every $c \in C$, $t(c)$ is a strictly decreasing function

A11 for every $c \in C$, $t'(c)$ is a weakly increasing function[16]

Axioms six through nine are unrealistic in that they call for constant marginal yields and costs. In the real world variable marginal

[16] Empirical verification of this form of the transport cost function may be found in C. N. Phillips, "Economics and Developments to Expect in Transporting Energy," *Edison Electric Institute Bulletin*, Vol. 21 (1953), p. 273, and in Edgar M. Hoover, *The Location of Economic Activity* (New York: McGraw-Hill Book Co., 1948), pp. 19–21.

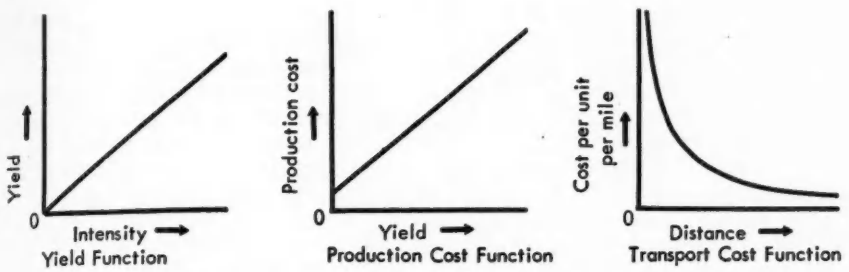

FIG. 1. Yield, Production Cost, and Transport Cost Functions for the Linear Case.

costs and yields are often observed, and it is proposed to set up an alternate set of axioms which will describe the desired non-linear cost and yield functions (Fig. 2).

A7* for every $c \in C$, $y'(c)$ is strictly decreasing

A9* for every $c \in C$, $a'(c)$ is weakly increasing

If these two axioms are inserted in the model in place of the corresponding linear functions, the more realistic non-linear case is obtained.

The Rent Function

From the above axiom, the rent received from the operations of the farm business will be defined as:

$$R(c,m,x) = y(c,x)\,[p(c,m) - a(c,x) - t(c,d(m)) \cdot d(m)].$$

In other words, net return is equated to the gross return, $[y(c,x) \cdot p(c,m)]$, less production costs, $[y(c,x \cdot a(c,x)]$, and transport costs to market, $[y(c,x) \cdot t(c,d\,(m)) \cdot d\,(m)]$.

EXISTENCE THEOREMS

It will now be shown that for every location there exists some combination of crops, intensities of cultivation, and markets which will permit the agricultural entrepreneur to maximize the rent function defined above; that is, that there exists a $c_1 \in C$, $m_1 \in M$, and $x_1 \geqslant 0$ such that,

$$R(c_1, m_1, x_1) = \max_{c \in C} \max_{m \in M} \max_{x \geqslant 0} R(c,m,x).$$

Heuristic Argument[17]

The agricultural entrepreneur attempting to maximize his rent function may be thought of as making a choice among the elements of a three-dimensional matrix having the dimensions: crops by markets by intensities of cultivation. (This matrix will hereafter be referred to as the "choice matrix.") The entrepreneur's choice matrix is finite in the two dimensions crops by markets and is infinite with reference to intensities; therefore the element representing the optimum choice

[17] "A heuristic argument is an exploratory thinking process, not necessarily strictly logical, which seeks to *discover* a logical procedure for solving the problem," *Universal Mathematics, op. cit.*, pp. viii–18.

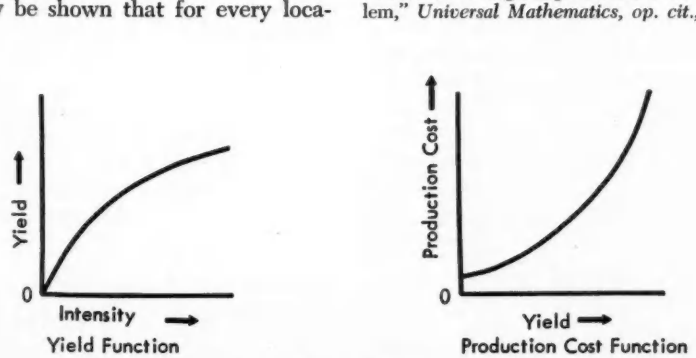

FIG. 2. Yield and Production Cost Functions for the Non-linear Case.

(i.e., the maximum rent level) cannot be found in any finite length of time.

If the infinite dimension, intensity, could be shown to have a maximum, the operator's choice matrix would become finite in the two dimensions crops by markets, and then could be solved by inspection within a finite time period.

It follows that the proper strategy to use in proving the existence theorems is to show that a maximum exists for

$$\frac{\delta(\max \max R[c,m])}{\delta x};$$

the desired proof will then follow directly.

Proof in the Linear Case

Let "k" be equal to the per unit market price discounted for transportation costs, then for some $c_i \epsilon C$, and $m_i \epsilon M$:

$$R(x) = ky(x) - y(x)a(x) \qquad (1)$$

The marginal rent function is obtained by taking the first derivative of equation (1) with respect to x:

$$R'(x) = ky'(x) - y(x)a'(x) - a(x)y'(x) \quad (2)$$

From axioms seven and nine it is evident that

$a'(x)$ is a constant (hereafter known as α) > 0.

$y'(x)$ is a constant (hereafter known as β) > 0.

With this information equation (2) may be reformulated as:

$$R'(x) = \beta k - \alpha y(x) - \beta a(x) \qquad (3)$$

At the point where the rent is a maximum, equation (3) will be equal to zero. The second derivative of the rent function is then obtained by finding the derivative of equation (3) with respect to x:

$$R''(x) = 0 - \alpha\beta - 0 - \alpha\beta - 0 = -2\alpha\beta \qquad (4)$$

Since it is known from the axiom system that α and β are always positive, it follows that the second derivative is at all times negative and hence a relative maximum exists for x. It then follows directly that a maximum must exist for the rent function.

Since an optimum level of intensity exists, it becomes appropriate to attempt to discover what relationship, if any, exists between intensity and location. This is accomplished by solving equation (2) for x.

From axioms six through nine, it is apparent that $a(x)$ has the general form $\alpha x + \alpha_0$ and that $y(x)$ has the general form $\beta x + \beta_0$. If these general forms are substituted in equation (2) we obtain:

$$R'(x) = \beta k - \alpha\beta x - \alpha\beta_0 - \alpha\beta x - \alpha\beta_0 = 0 \quad (5)$$

Solving equation (5) for x, we obtain:

$$x = \frac{\beta k - \alpha\beta_0 - \beta\alpha_0}{2\alpha\beta} \qquad (6)$$

It seems reasonable to assume that even when no crop is grown the land may be subject to certain fixed charges such as taxes (i.e., $\alpha_0 \neq 0$), and that if there is no input of at-site factors there is no crop output (i.e., $\beta_0 = 0$). With the addition of these restrictions, equation (6) reduces to:

$$x = \frac{k - \alpha_0}{2\alpha} \qquad (7)$$

Equation (7) states that the optimum level of intensity is directly proportional to the difference between the local price and the fixed charges on the land, and inversely proportional to twice the marginal production cost. Since local price varies in an inverse fashion with distance from market, intensity of cultivation will also vary inversely with this distance, in the special case where all α's are equal.

The Non-linear Case

The first proof of the existence of an optimum level of intensity utilized certain assumptions regarding the linearity of the yield and production cost functions. The problem becomes more difficult of solution when the more general non-linear case is considered. If axioms A7* and A9* are substituted for axioms A7 and A9, the required non-linear case is obtained.

Setting equation (2) equal to zero, the general second derivative with respect to x is:

$$R''(x) = ky'(x) - 2a'(x)y'(x) - y(x)a''(x) - a(x)y''(x) \qquad (8)$$

Collecting terms, equation (8) becomes:

$$R''(x) = [k - a(x)]\, y''(x) - 2\, a'(x)y'(x) - y(x)a''(x) \qquad (9)$$

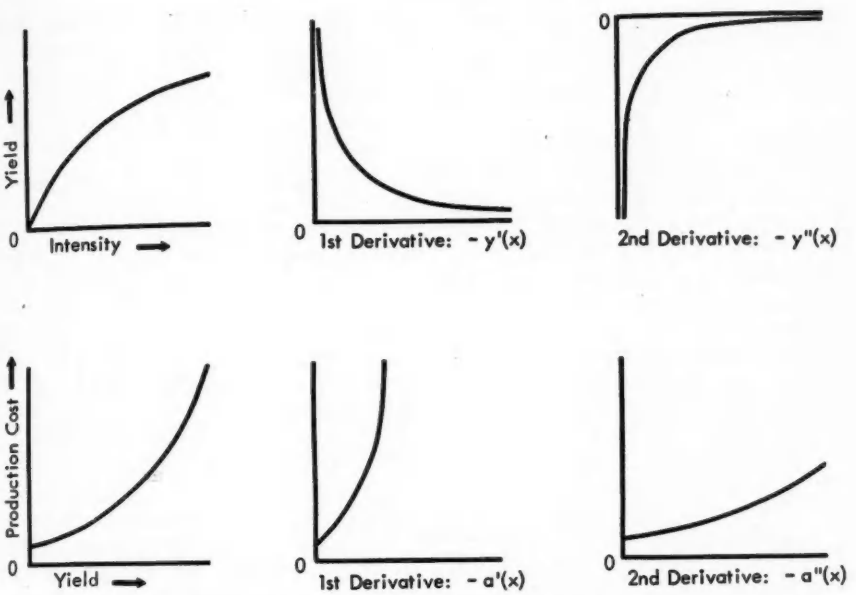

FIG. 3. Derivatives of the Yield and Production Cost Functions for the Non-linear Case.

The terms $[-2a'(x)y'(x)]$, $[-y(x)a''(x)]$, and $y''(x)$ are by definition always negative (Fig. 3). Hence in order to insure that $R''(x)$ is always negative, the limiting restriction $[k - a(x)]>0$ must always be in effect. This means that any level of intensity which causes the cost of production to exceed or equal gross profits is not a solution. If this restriction is in effect then an optimum level of intensity exists and it follows that the choice matrix in this case is finite in two dimensions, and hence can be solved in some finite length of time.

The above proof of the existence theorem in the non-linear case completes the general proof of the theorem. While it is not feasible to give an exact definition of x in the non-linear case, the property of x which characterizes the set of all possible solutions in the non-linear case has been identified. Whether the set of all solutions in this case contains one or several members should be the subject of further inquiry.

SUMMARY AND EVALUATION OF THE FINDINGS

In the preceding sections of this study a model, in axiomatic form, of the farm business was constructed. This model differed from most previous works in the field in that it was (1) more rigorous in its presentation, and (2) directed toward analysis on the level of the individual entrepreneur rather than on the industry level. It was shown that the theorem—for every location there exists some combination of crops, markets, and intensities of cultivation which will enable the farm operator to maximize his net returns—was a logical consequence of the structure of the model. Also, an explicit definition of intensity was developed for the simple linear case.

Existence of an optimum solution. The most important theoretical result of this study was the rigorous verification of the long-held intuitive idea that an optimum agricultural land use, in terms of maximization of net returns, does exist for every location. This proof immediately puts most existing theoretical and empirical work regarding the areal arrangement of agriculture upon much firmer ground than was previously true. The solution provides a useful pedagogical addition to current explanations of agricultural patterns and may assist in the development of a more realistic basis for empirical work.

Uniqueness of the optimum solution. The proof of the existence theorems did not, how-

ever, establish that the optimum solution was unique. There is nothing present in the system that would prevent two or more elements of the choice matrix from having the same value.

The possibility of indifference, on the entrepreneur's part, between two land uses which would both produce the same rent has not been considered in the literature. From the way in which the optimum solution was defined, however, it is obvious that the operator must limit his selection to that land use, or group of uses, which would produce both maximum rent and minimal at-site input demands.

Intensity of cultivation and distance to market. The conclusions reached regarding the relationship existent between distance and intensity are similar to those reached by Dunn.[18] That is, if only a single land use and production function is considered, the intensity of cultivation will increase continuously as the market is approached; however, if more than one type of land use is considered, or if more than one production function is present, it is entirely possible that land uses closer to the market may have lower intensities of cultivation than those further away. In this sense the study acts as a confirmation and extension of previous theoretical works.

ADDITIONAL PROBLEMS

There are four directions for further research which would seem to be logical developments of the work presented here. They are discussed in increasing order of importance and difficulty of solution.

Size of the farm unit. Throughout the analysis presented in this study nothing has been said about the size of the farm unit. The size of farm would be expected to have a definite effect upon the operator's actions in maximizing his rent function. This variable was not initially included in this study because it was felt that the model might become too complex to permit ready solution. It is suggested that any further theoretical investigations include size of the farm unit as an explicit variable.

Formulation of a general location model. It was pointed out that certain differences exist between models in industrial location and those in agricultural location. It is felt that if non-zero procurement distances could be incorporated into the model presented here, and the existence theorems proven in this more general case, the whole body of theory would rest on a much firmer base than is presently the case.[19]

Reconciliation of approach levels. Most theoretical constructs prior to this time have been concerned with problems at the level of the industry rather than the level of the individual firm. A theoretical structure which will reconcile these two approaches is urgently needed.

Formulation in terms of social costs. This study, as well as all previous works in the field, has treated the entrepreneur as a person interested only in maximizing his net profits. Actually, experience has shown that maximization is more likely to be in terms of personal *satisfaction* than personal profit. On the empirical level, measurement of satisfaction presents problems of extreme complexity; however, it seems that future work on both the theoretical and empirical levels must incorporate this concept if our understanding of the spatial organization of human activities is to increase.

[18] *The Location of Agricultural Production, op. cit.*, pp. 44–45.

[19] The importance of procurement distances in the evaluation of sites by farmers has been described in William L. Garrison, "Verification of a Location Model," *Northwestern University Studies in Geography*, Vol. 2 (1956); "Estimating the Parameters of Spatial Interaction," Regional Science Association, *Papers and Proceedings*, Vol. 2 (1956), pp. 280–288, and *The Benefits of Rural Roads to Rural Property, op. cit.*

THE STATUS OF "CONIFERS" IN VEGETATION CLASSIFICATIONS[1]

DAVID J. DE LAUBENFELS
University of Georgia

VEGETATION CLASSIFICATION

THE purpose of vegetation classification is to subdivide the natural plant cover in some rational way. Numerous systems can be devised to classify the vegetation of the world. Any classification which assumes that each of its subdivisions displays many fundamental traits characterizing that subdivision whenever it occurs is a "natural" system. If the subdivisions do not bear a large number of traits in common, the system is referred to as "artificial." Thus a classification based on the age of the individual plants contained in the subdivisions would be considered artificial. Because it is not possible to give attention to all the important traits present in a natural classification, certain "classificatory characters" or key traits are often utilized. As an example, the presence of mammary glands distinguishes the Mammalia from all other vertebrate animals, although it is understood that mammals also have many other traits in common. Some systems of classification do not lend themselves to cartographic presentation and will not be considered here. The purpose of this paper is to examine the role of "conifers" in continental and world vegetation classifications.

"CONIFERS" IN THE LITERATURE

Among the maps of world or continental vegetation distribution usually used by the American student of geography, conifers have a virtually unchallenged position in classification. More particularly, conifers are used to distinguish larger vegetation groups, including those of world-wide distribution. Thus, for example, middle latitude forest is often divided into the three categories: coniferous, non-coniferous, and mixed (coniferous and non-coniferous). The concern here is not with some natural vegetation formation that has had some particular conifer selected as a classifying character; the concern here is with those forest types which essentially lump together as a unit many distinct formations simply because they are dominated by conifers.

The vegetation maps best known to geographers are those in the atlases. The map by Linton in the *Oxford Atlas* has thirty-nine vegetation categories, of which twenty-one are forest.[2] The forests are divided into temperature zones within which, in some cases, are moisture distinctions. The individual categories within most of the forest zones are then given as coniferous, mixed, and some kind of supposedly non-coniferous vegetation, such as deciduous forest. Küchler presents thirty-two types of natural vegetation in *Goode's School Atlas*.[3] He classifies trees physiognomically into various types including needleleaf forms by which, he explains elsewhere, he means all conifers.[4] The result is that of his eight kinds of area characterized by trees, two are coniferous (one evergreen and one deciduous), and three are mixed, including coniferous. A vegetation map in a recently published agricultural atlas of Europe and the Near East includes both coniferous and mixed forest in its classification.[5]

Various more generalized vegetation maps than the above are readily available to the geography student. In nearly every case, coniferous forest appears as one of approximately a dozen vegetation types. Many widely used college textbooks in geography include such

[1] The author wishes to express appreciation for the many helpful comments given by Dr. Frank E. Egler in the writing of this paper. Thanks are also due to Dr. John W. Marr, who read the paper and made constructive suggestions.

[2] D. L. Linton, "Vegetation," *American Oxford Atlas*, ed. by C. Lewis, J. D. Campbell, D. F. Bickmore, and K. F. Cook (New York: Oxford University Press, 1951), plates VIII and IX.

[3] A. W. Küchler, "World Natural Vegetation," *Goode's School Atlas*, edited by J. Paul Goode and Edward B. Espenshade (Chicago: Rand McNally, 1950), pp. 16–17.

[4] A. W. Küchler, "A Physiognomic Classification of Vegetation," *Annals*, Association of American Geographers, Vol. 39 (1949), pp. 201–210, esp. p. 203.

[5] Office of Foreign Agricultural Relations, *Agricultural Geography of Europe and the Near East*, Miscellaneous Publication 664 (Washington: Government Printing Office, 1948), p. 13.

maps.[6] The vegetation maps in some atlases fall into the same category.[7] Similar maps also appear in other places, as, for example, a recently published map of the western hemisphere which includes a map of natural vegetation as an inset.[8]

Other generalized vegetation maps are less often quoted by geographers. The physiognomic vegetation system of Rubel refers to the conifer forests of the northern hemisphere by the terms Nadelgehölze and Aciculilignosa.[9] One of the best known, and often criticized, North American systems is that of Weaver and Clements.[10] In this system, the life-form of the dominant plants is the most important single criterion of classification and "evergreen trees [are not] proper dominants of deciduous forest."[11] Their map of North American vegetation types separates the evergreen coniferous types from deciduous forest. The well-known map of Shantz and Zon segregates various coniferous forests dominated by pines, spruce, and firs.[12] The North American vegetation type map of Transeau has eleven categories of which five are either coniferous or deciduous, and one is mixed.[13]

[6] See, for examples, V. C. Finch and Glenn T. Trewartha, *Physical Elements of Geography* (New York: McGraw-Hill, 1949), plate VI; H. M. Kendall, R. M. Glendinning, and C. H. MacFadden, *Introduction to Geography* (New York: Harcourt, Brace and Co., 1951), plate VII; L. E. Klimm, O. P. Starkey, and N. F. Hall, *Introductory Economic Geography* (2nd ed.; New York: Harcourt, Brace and Co., 1940), fig. 82; N. A. Bengtson and W. Van Royen, *Fundamentals of Economic Geography* (3rd ed.; New York: Prentice Hall, 1950), p. 88; A. N. Strahler, *Physical Geography* (New York: John Wiley & Sons, 1951), fig. 23.2.

[7] See, for examples, John Bartholomew, *The Advanced Atlas of Modern Geography* (New York: McGraw-Hill, 1950), p. 20; and *Hammond's Collegiate Atlas* (New York: C. S. Hammond and Co., 1950), continental vegetation maps on pp. 11, 23, and 31.

[8] American Geographical Society, *Map of the Americas* (New York, 1953).

[9] Edward Rubel, *Pflanzengesellschaften der Erde* (Bern-Berlin: Hans Huber, 1930).

[10] John E. Weaver and Frederic E. Clements, *Plant Ecology* (McGraw-Hill, 1929), frontispiece.

[11] *Ibid.*, p. 422.

[12] H. L. Shantz and Raphael Zon, "Natural Vegetation," *Atlas of American Agriculture* (Washington: U. S. Government Printing Office, 1924).

[13] E. N. Transeau, H. C. Sampson, and L. H. Tiffany, *Textbook of Botany* (New York: Harper and Sons, 1940), p. 741.

CONIFERS AS A PHYLOGENETIC GROUP OF PLANTS

In order for conifers as a group to serve faithfully in distinguishing broad vegetation types, they should exhibit certain unique characteristics by which they can be recognized as a vegetation form. Conifers do have a number of important characteristic traits. Here is a group of related seed plants which reproduce by means of cones. Details of the internal structure of the leaf, wood, and root are different from other kinds of plants. Unfortunately, microscopic study would often be necessary to recognize these distinctions in order to label some unknown plant as a conifer. Superficially, the various organs of conifers can bear a striking resemblance to the corresponding organs in non-conifers. Even the cones can be modified beyond recognition. Some conifers bear catkins of pollen-bearing organs; young cones sometimes resemble flowers complete with violet or yellow "petals." Plum-like fruits (often edible) are much commoner than may be realized. On the other hand, cone-like structures are at times seen on non-coniferous plants.

There are various traits popularly but incorrectly ascribed to conifers: they are needle-leaved, evergreen, softwoods. Although needle-shaped leaves commonly occur among conifers, they form only one of four basic leaf types displayed by this group of plants.[14] Broad leaves of linear or ovate shape and scale leaves are the other three types. A number of conifers are deciduous, including the bald cypresses of southern North America and the larches of the higher northern hemisphere latitudes. As for wood, that of many conifers must be called "hard" while a great number of other plants have wood that must be called "soft." Wood is, furthermore, not an externally recognizable quality of vegetation.

As individual plants, various conifers actually resemble non-conifers more than other conifers. The "bunya-bunya" of Australia (*Araucaria bidwillii*) is a forest tree with medium-sized broad and pointed leaves. At maturity the cone shatters and releases huge egg-shaped nuts that are an important food of the aborigines. The "lleuque" of Chile (*Podocarpus andina*) resembles non-conifer forest trees with its flat linear leaves an inch or two

[14] D. J. de Laubenfels, "The External Morphology of Coniferous Leaves," *Phytomorphology*, Vol. 3 (1953), pp. 1–20.

long. In the fall, this tree yields yellowish "plums" that the country people find very tasty. One podocarp inhabits the rainforests of the East Indies (*Podocarpus amarus*). Not only is its fruit a drupe, but the leaves have the usual size and ovate shape of rainforest trees, even to including the characteristic "drip tip" that protrudes at the leaf apex. Other podocarps live in the thorn forests in various parts of South America. The small, sharp-pointed but not needle-shaped, leaves are indistinguishable from the general leaf types of its neighbors. One cannot look at an unknown plant and say, "That is a conifer" or "That is not a conifer."

Fundamentally, the term "conifer" refers to plants of the order Coniferae, one of seven orders of the Gymnospermae. Included in this order are the araucarias of the southern hemisphere, the cephalotaxads of eastern Asia, the pine-fir-spruce-larch-hemlock group of the northern hemisphere, and the widespread podocarps, taxads, and "cedars," not to mention several less important groups. The order comprises plants with a common evolutionary ancestry but with extremely diverse physiognomy.

THE ECOLOGY OF CONIFER SPECIES

If conifer species were similar in their ecological and vegetational relationships, there would be reason for using them as a classificatory character in the mapping of vegetation. A survey of merely the needle-leaved evergreen trees, however, shows remarkable diversity. They vary as to stage of succession on uplands; they vary in local moisture relationships; they vary with respect to precipitation from desert to rainforest; and they vary with respect to temperature from the tropics to polar cold.

Climax forests of the northern hemisphere include species of pine, fir, spruce, and hemlock. The white pine in New England is famous for its success in invading abandoned "old fields." Lodgepole pine in the north and the southern pines are recognized for their ability to follow fire while the Douglas fir of the Pacific Northwest is said to rely on fire to help it compete with hemlock. In central New York state, conifers such as white pine are most common in moist places while the general vegetation is non-coniferous. Exactly the reverse situation prevails in the forests of western Oregon. Piñon pines grow in or near many desert areas of our West. The water-logged coasts of the Northwest have dense forests of spruce, fir, and hemlock. Caribbean pine grows in tropical savannas from eastern Nicaragua to western Cuba. Lodgepole pine grows to the most remote Arctic timberline. Species of conifers, even limited to needle-leaved evergreen trees, occur in practically every known forest habitat, ecological and edaphic, and therefore are not indicative of any significant difference in vegetation.

CONIFEROUS COVER TYPES

The term "cover type" refers to a plant community that actually exists on the land surface, regardless of its ecological position or its relation to other cover types. A cover type is one of the smaller units in vegetation classification. Cover types are generally named for the predominant species present within them. The consideration of coniferous cover types simplifies the discussion because only those conifers of sufficient abundance to dominate the landscape need be included. Many of the species mentioned in the preceding section dominate cover types. They represent widely divergent regions. Partly as an expansion of the foregoing, the diversity of coniferous cover types can be expounded.

Along the northwest coasts of the United States and northward to Alaska grows a magnificent forest of conifers. These trees are evergreen and the dense growth of the crowns allows little light to reach the forest floor. There in the semi-darkness grow large ferns and great quantities of moss.

In northern Finland is an open woodland of spindly conifers that are very old in spite of their small size. Between them grow various shrubs and abundant lichens of the tundra type. Some of the trees are evergreen and some deciduous.

Along the Caribbean coast of Nicaragua and Honduras is found a light forest of pines growing above a carpet of coarse tropical grass. Fires during the dry season tend to limit the number of trees. Epiphytes grow among the tree branches.

Over vast semiarid areas of the American mountain states grow small, bushy, scale-leaved junipers ("cedars"). Sometimes, where fire has been rare, these junipers form a low forest

that crowds the sparse grass and other herbs and the low shrubs.

Much of the American South and other areas as well have a fine forest of pines mixed with variable amounts of broad-leaved deciduous and evergreen trees. In contrast to several of the foregoing, the canopy is closed; that is, the branches of the trees meet and light penetrates only as flecks or in a diffuse state. Large shrubs are not common, but various herbs cover the forest floor. In some places, vines make something of a tangle among the trees.

Whether or not the cover type of a particular area is dominated by conifers may depend on the type of interference that has occurred. Examples of both increase and decrease of conifers due to the activities of man can be drawn from New England. Abandoned agricultural land was taken over almost completely by conifers some time ago. Selective logging of these conifers for lumber and pulp has returned the forest to non-conifers again, although generally to different species of trees. Fire in its relationship to conifers has already been mentioned.

As with conifer species, coniferous types occupy an extremely wide range of ecological positions. In view of this fact, coniferous cover types cannot be said to have any unique ecological characteristics.

THE DEGREE OF CONIFER ECOLOGICAL DOMINANCE

In spite of the great diversity of coniferous cover types, it might reasonably be asked whether conifers are not essentially dominant in certain broad ecological areas. This line of thought can take two directions. Do conifers actually dominate in the areas they are generally credited with covering and do alternative areas exist without conifer dominance that ecologically correspond to conifer areas?

Short of misinformation, conifers are of major importance in those areas actually designated as coniferous. On the other hand, there is serious question whether any such area is sufficiently continuously coniferous to justify more than arbitrary classification as such. Take, for example, the so-called "northern coniferous forest," the region of the world most dominated by conifers. Even here broad areas are dominated by birches, aspens, and cottonwoods (as well as the deciduous conifer, the larch or tamarack).

The degree to which conifers fail to appear in equivalent ecological sites is significant. The coastal forests of northwestern United States and Canada are primarily coniferous. Almost identical ecological conditions reappear in southern Chile where small-leaved evergreens dominate, of which only ten percent are conifers. Eucalyptus forests hold sway in eastern Australia in environments similar to pine forests in the coastal plain of southeastern United States. Conifers are important, if not dominant, in the forests of New Zealand while closely comparable areas of England almost completely lack conifers.

CONCLUSION

Conifers as a group do not possess the uniformity necessary, as a group, to distinguish a larger subdivision of any natural vegetation system. They differ widely in appearance, in the ecological areas they occupy, and in the cover types that they dominate.

It is possible to employ conifers in various ways in artificial vegetation classification systems. The most obvious is the wholesale separation of vegetation on a taxonomic basis, a system that assuredly has little use. More practical are systems that are limited to some large portion of all conifers. Because conifers with needle-shaped leaves are so common, a map of needle-leaved forest (coniferous) therefore becomes possible.[15] The value of such a map lies in the fact that the single trait can be readily recognized. Generally speaking, for lumber interests "softwood" trees of the northern hemisphere are also conifers.

The question naturally arises, how should these broad areas, commonly called coniferous, be classified? Such classification is always a knotty problem at best and fundamental thinking in the classification of vegetation has yet to be done. As a first step, the kinds of vegetation units in use should be considered. Nearly all of the maps referred to earlier contrast coniferous forest with vegetation described in some other way. The major contrast is made with deciduous forest or with temperate forest.

[15] A. F. W. Schimper, *Pflanzengeographie*, ed. by F. C. von Faber (3rd ed.; Jena: G. Fischer, 1935), Vol. 2, Karte 3. The classification used on this well-known map is widely used by ecologists and plant geographers.

The same maps also carry such classifications as broadleaf evergreen forest or tropical rainforest. Whatever method is employed, it should be consistent. Physiognomic techniques stressing leaf characteristics are basically artificial systems.

Natural systems, such as those that use descriptive vegetation terms, would scatter conifers into many categories. The great boreal forests famous for their conifers would take a large part of the area in which these plants are important.[16] Temperate forests and temperate rainforest would include other large conifer areas. Still other formations, such as thorn forest, savanna, and the Mediterranean woodland type, would also claim conifer forests.

When producing maps of continental and world vegetation distribution, the plant geographer should not emphasize the taxonomic plant distinctions. In the case of conifers, a most used vehicle, the overwhelming diversity of the result has been shown. The plant geographer should strive to recognize and emphasize those divisions and subdivisions of vegetation which have uniformity or homogeneity of many basic vegetative attributes.[17]

[16] See F. Kenneth Hare, "The Boreal Conifer Zone," *Geographical Studies* Vol. 1 (1954), pp. 4–18. Dr. Hare feels that including the boreal forests within the general vegetation type "coniferous forest" is not proper because the latter is both vague and unsatisfactory, because other coniferous forests are phytogeographically and ecologically distinct, and because the boreal forest is by no means exclusively coniferous.

[17] For a recent detailed exposition of this kind of description, see Pierre Dansereau, "Description and Recording of Vegetation upon a Structural Basis," *Ecology*, Vol. XXXII (1951), pp. 172–229. An excellent study of a limited area recently published separates the plant cover into "zones" that are vegetationally homogenous in all their aspects: Emil Schmid, *Vegetations-karte der Schweiz*, in four sections (Bern: Hans Huber, 1949–1950).

ABSTRACTS OF PAPERS PRESENTED AT THE 53rd ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS, CINCINNATI, OHIO, APRIL 1-4, 1957

CHARLES S. ALEXANDER—*The Marine Terraces of Curaçao*

Five marine terraces are found along the coast of Curaçao. The first, third, and fifth are well defined and are nearly continuous around the island. The escarpment of the second terrace has been cut only slightly below the platform of the third. The fourth terrace occurs only locally, confined to areas of greater uplift.

During the late Pliocene and early Pleistocene, Curaçao was beneath the sea and a coral limestone cap, up to 150 feet thick, was laid over the island's basement rocks. Starting in the early Pleistocene, and continuing throughout that epoch, the island was uplifted and the coral cover anticlinally folded; during this period terrace cutting occurred. Careful elevation measurements of the terraces indicate that the uplift of the island has been continuous.

Under conditions of continuously rising land, eustatic changes in sea level are necessary for the development of a succession of marine terraces. With stable sea level, a continuously rising coast will produce either a widening coastal plain or a cliff of increasing height but not terraces. Thus the terraces of Curaçao must be the result of erosion during interglacial or preglacial high sea levels.

The evidence presented indicates that the first terrace dates from the Sangamon Interglacial while the third is the result of the Yarmouth Interglacial. The second terrace appears to be closely related in time to the third; so it is assigned to an early interstadial of the Illinoian glaciation. The fourth terrace is correlated with the Aftonian Interglacial, and the fifth terrace represents a high stand of the sea in the preglacial Pleistocene.

LEWIS M. ALEXANDER—*Conflicting Claims to Sovereignty over Sea Areas*

With the increased development of resources in and beneath the seas of the world there has been a corresponding increase in the number and complexity of claims to sovereignty over sea areas. Conflicting concepts exist in three principal fields: width of the territorial sea, methods of delimiting the outer limits of the territorial sea and of the continental shelf, and types of sovereignty to be exercised over the continental shelf.

Despite the efforts of geographers and international lawyers—particularly in the United States—toward standardization of these conflicting concepts the trend among most nations in recent years has been towards greater flexibility of application. As a result international tension has developed in a number of situations due to the ambiguity of principles and of geographic terms relating to the political partitioning of sea areas.

Four examples of conflicting claims are considered briefly: (1) the disputed waters between Japan and the Republic of Korea, (2) the development of oil resources in the Persian Gulf, (3) the fisheries dispute between Japan and the Soviet Union, and (4) the width of the territorial seas off the Latin American coasts. In each instance it may be shown that the lack of universally-accepted principles of sovereignty has been responsible for the creation of international tension. Through the application of concepts of sovereignty to specific conditions in coastal areas geographers can aid in effecting a rational approach to the problem of national claims to sea areas.

JAMES R. ANDERSON—*Some Regional Aspects of Agricultural Land Use and Development in the United States*

In recent years, production from American farms has been out of balance with market demand. However, the rapid growth of population and the prospect of a higher level of consumer purchasing power remind us of the need for increasing and adjusting the Nation's agricultural production over the longer period of time.

When alternative ways of meeting these long-run food requirements of the Nation are considered, the amount of land potentially available for crops and pasture should be evaluated. Over-all possibilities for the development and improvement of land may be examined by comparing present land uses with potential uses based on estimates of the acreage

of land physically capable of being used for various purposes. These possibilities and the potential shifts in land use are analyzed by regions.

Over-all changes in land use which have taken place do not adequately reflect some of the regional shifts that are occurring. Another important change that is not reflected in the acreages of land used for different purposes is the development of new cropland, the revision of cropland to pasture and woodland, and the conversion of agricultural land to other uses. In some parts of the country, land that is physically better adapted to crop production is replacing land used for pasture or woodland. In other areas where industry and urban development have expanded rapidly, areas of good agricultural land are being permanently converted to nonagricultural uses. These regional differences in land use and development are an outstanding feature of American agriculture.

WILLIAM APPLEBAUM — *Cincinnati Business Centers: 1931–55*

A quarter century ago the author made a study of the outlying business centers of Cincinnati (the central business center was excluded). The study proved useful to city planners, retail firms, commercial real estate owners, and urban geographers.

The phenomenal development of planned, integrated shopping centers has intensified interest in all types of business centers. This recent follow-up study deals with (1) the changes that have taken place between 1931 and 1955 in the business centers originally studied, (2) the new business centers that have emerged in the area originally studied, (3) new planned shopping centers emerging, and (4) the outlying business centers in Hamilton County outside the area originally studied.

Striking changes have occurred in the number and types of business establishments between 1931 and 1955. Shopping goods stores show the greatest gains. Manufacturing and wholesaling, nonexistent in 1931 in outlying business centers, have become significant in 1955. Average business frontage per store has increased for most types of stores. While the total number of business establishments in the business centers studied both in 1931 and in 1955 has increased 31 per cent, total frontage has increased 90 per cent.

Of 111 business centers studied in 1931, seven disappeared by 1955 and five became merged with neighboring centers; 25 new business centers have emerged. For every business center showing a decrease in number of establishments, three show an increase; the decreases are small while the increases are large.

The development of planned, integrated shopping centers has been slow in coming to Cincinnati, but since 1954 several substantial planned centers have been developed. A number of older centers are likely to be affected by these new developments. To meet the competitive challenge they must find ways to provide better parking and to improve the character and merchandising of the stores.

ROLLIN S. ATWOOD—*Regional Geography in Action: The "Plan Chillan" of Chile*

A little over three years ago, during an informal discussion of economic and social problems, a group of Chileans and Americans laid the groundwork for what is today one of the most successful as well as most challenging regional development programs in this hemisphere.

For the geographer it provides a living, breathing example of regional geography being acted out by real people on a real stage. The effects of physical factors are being felt by living people every day. The same is true with regard to economic factors, political factors, historical influences, social customs, educational patterns, etc.

The region was not chosen on the basis of physiography, climatology, soils, or vegetation. It was chosen as an area where a serious problem facing the economic stability of Chile could be effectively attacked with the facilities available. It was chosen as the food and raw material producing hinterland of Chile's fastest growing, most rapidly industrializing, deep-sea port—Concepcion. It was also chosen as an agricultural area where the vast majority of the persons own and live on the land. It was outside the area of absentee ownership. It was a region that was feeling the inflationary effects of rapidly increasing market demand both from Concepcion and from the capital city of Santiago approximately 250 miles to the north.

It was a region far enough from the political capital to permit decentralized operation and thus to coordinate the technical cooperation activities of the Chilean ministries of agriculture, health, public works, transportation, and the Chilean National Development Corporation as well as the technical cooperation provided by the Institute of Inter-American Affairs of the United States.

Geographically the area selected includes the three Chilean provinces of Maule, Nuble, and Concepcion. It is centered around the town of Chillan 250 miles southwest of Santiago and approximately 100 miles east of Concepcion. The region contains about one-eighth of the total population of Chile of which about 58 percent is urban and 42 percent rural. This corresponds closely to the general distribution of population in Chile. The region contains something over 10 percent of Chile's crop land and about 15 percent of its pasture land.

JOHN P. AUGELLI—*The Japanese of Bastos and the Latvians of Varpa: A Comparison of Cultural Adjustment on the Brazilian Pioneer Fringe*

The objectives of this paper are to compare the adjustment of two distinctive cultural groups to a similar environment, and to shed some light on the "foreign agricultural colony" as an instrument of settlement in the Brazilian interior. Japanese Bastos and Latvian Varpa are located within 15 miles of each other in the Rio Peixe Valley of São Paulo's pioneer fringe. Field investigation revealed that there was little difference in the physical setting and the economic possibilities under which these two agricultural colonies developed. Moreover, the two were founded at approximately the same time; both groups were made up largely of peasant farmers; the average farm size per colonist was the same in both; both were about the same distance from the railroad and faced comparable transportation difficulties. There were some initial differences, such as the numerical size of the groups, the motive for immigrating, and the degree of orientation and control from the home country. In essence, however, the most striking difference between the two was the "cultural baggage" with which the two groups arrived in Brazil.

After existing side by side for about 30 years, Bastos and Varpa currently reveal interesting similarities and marked differences. These are reflected on the landscape by land-use patterns, buildings, crop and animal associations, agricultural practices, and other phenomena. They are also mirrored within the groups by language, religion, education, diet, health, and general social values. The comparison permits some generalization concerning the patterns and problems of cultural adjustment.

ALBERT G. BALLERT—*The Nature of the Great Lakes Ports*

This paper and the accompanying map are directed toward achieving a better understanding of the principal ports of the Great Lakes. Included in this group are the million-ton ports, which number between 55 and 60.

These focal points for the preponderance of all Great Lakes commerce vary widely in volume, variety, and direction of movement of their commerce. The map presented summarizes these facts for the 1955 navigation season. It is a revision of the author's earlier published map based on 1948 data.

The nature of the Great Lakes ports cannot be satisfactorily pictured by viewing only the commerce. The localities associated with the port facilities, for example, show great variance with respect to such features as size, economic activity, degree of dependence on port activities, and extent of hinterland and foreland. In some ports the economic gains to the community may be primarily indirect. Such a port is Toledo, where railroad employment stands to benefit perhaps most from the vast lake coal shipments. At a number of ports a single industry located on the waterfront is the community's sole or primary source of economic livelihood. Outstanding in this respect is the new port at Silver Bay, Minnesota. At still other million-ton ports there is no urban settlement.

Much attention has been given in recent years to the classification of urban areas according to their functions. Here the attempt has been to find a variety of bases for classifying the principal Great Lakes ports. This report in combination with the statistical map suggests some aspects of the nature of these ports and directions for further investigation.

JAMES A. BARNES—*Control Areas and Control Points in Isopleth Mapping*

The utility of the isopleth map as a tool in

geographical research is an established fact, but the statistical validity of isopleth maps constructed by conventional methods is open to question. Analysis of the nature of the isopleth as a map symbol seems to indicate that such statistical validity hinges upon problems concerned with two variables: (1) the control area, defined as the areal unit used for the computation of the values used in mapping, and (2) the control point, the point at which the computed values are plotted for drawing isopleths.

Although general opinion may be to the contrary, this investigation suggests that the control areas must be of uniform size and shape, and that the control points must be located at the geometric centers of the control areas. The problem of maintaining these conditions can be solved by constructing an accurate uniform dot map of the distribution, disseminating the control points over the map mechanically, and establishing the values at the control points by measuring the absolute values (indicated by dots) within control areas of determined size (represented by a movable transparent circle). Variation in the size of control areas and variation of the frequency of control points can produce different maps from the same data. However, these factors can be controlled by the cartographer to produce results in conformance with desired standards. Theory and techniques are illustrated with maps of actual distributions.

JOHN F. BERGMANN—*Cacao in Early New Spain*

At the time of the Spanish conquest of the New World cacao was cultivated from about latitude 21° N. on the Pacific and Gulf coasts of Mexico through the Central American Isthmus to Costa Rica. The civilizations of highland South America did not use this native American crop plant, long cultivated and highly esteemed in pre-Columbian Middle America.

Southern Veracruz and Tabasco on the Gulf of Mexico along with Soconusco and Suchitepequez on the Pacific Coast of Guatemala were the heaviest areas of cacao production, although the Ulua Valley in Honduras and the Pacific slopes of El Salvador, Nicaragua, and Costa Rica were not insignificant. Large quantities of cacao beans, which served the native peoples as a form of currency and were the basis of a nutritious beverage, were sent annually to the lords of the Valley of Mexico as tribute from distant subject areas.

Aware of the local value of cacao, the Spanish conquerors diverted this tribute into their own coffers, increased the assessments, and caused new orchards to be planted. Oppressive methods, however, resulted in an early decline in the cacao industry, a decline which correlates closely with the sharp drop in population in the cacao districts during the sixteenth century.

Many corrective measures were suggested, including the resettling of native peoples in the depopulated cacao areas. But the colonial cacao industry never recovered, and later it was unable to compete with cheaper cacao from Ecuador and Venezuela, despite an increasing demand for this commodity after its introduction and acceptance in Europe.

RALPH E. BIRCHARD—*United States Cities with Populations of 50,000 and Over Dependent on Trade and Services*

The study determines for all cities of the United States of 50,000 people and over the approximate population dependent upon trade and services. The problem of calculation for most large cities is that of eliminating the manufacturing-dependent population. For a few cities population dependent upon other specialized functions must be excluded.

The writer's formula, developed to eliminate manufacturing-dependent population, is $(M - 15\%) + \frac{1}{2}(M - 15\%) = P'$. M is manufacturing employment as a percentage of the aggregate employment in manufacturing, wholesaling, retailing, and services; 15 percent is about the average M in highly commercial cities; and P′ is the percentage of city population dependent upon manufacturing. Therefore, $100 - P' = P$, the population percentage dependent upon trade and services. The formula assumes the four functions (and in a few cases, others) to be reliable for the purpose at hand. Even the most dominant manufacturing city retains 10 percent of its population as dependent on trade and services.

Cities with populations of 50,000 and over dependent on trade and services are shown on a map by size and categories. Seventeen cities of over 100,000 total population had populations below 50,000 dependent on trade and services (Table 1). Twenty-three others fell

from over 100,000 to between 50,000 and 100,000 (Table 4). Other tables relate each city's total population to its trade and services population.

It appears that the distribution of these cities under such analysis should give further insight into urban centrality for large cities in the United States. It may serve, also, for better identification of metropolitan places.

J. M. BLAUT—*Space, Time, and Process in Cultural Geography*

A meaningful distinction can be made between space-oriented and process-oriented thinking in cultural geography, between *structural* and *process analysis*, respectively. (*Functional analysis* can be distinguished as the short-term aspect of the latter.) While most work falls along a continuum between the two, current areal-differentiation theory underlies only the former, as well as an intermediate phase where process is called in to explain distribution. The latter approach treats space as an attribute of process, and concentrates on the behavioral and physical processes of resource utilization. Having rejected environmentalism, it must evolve "middle-range" theory bridging the gap between geographic research and general sociocultural theory.

This paper describes an effort along these lines, a study which attempted to handle process data, both functional and historical, in process terms. Commercialized Chinese mixed- and vegetable-farming systems in Singapore were investigated with a view toward determining tensions and weak points where planned development would be of use. The methodology developed involved four procedural stages: (1) definition of the space-time "field" of resource-using processes; (2) definition and abstraction of component elements, valuative, behavioral, and physical; (3) examination of each element as to its mode and degree of integration in the process field, by functional and historical analysis; (4) construction of functional interaction models for the field. It was found that functional analysis had to be dovetailed with historical analysis to isolate significant elements and determine certain functional relations not revealed by fieldwork. Structural analysis, though secondary, was essential: e.g., in the defining stages, and in verifying some Chinese origins by present-day distribution. In the approach outlined here, description and explanation fuse, and "relationships" become tangible, culturally determined processes. It is concluded that process analysis, functional and historical, integrates cultural geography with the other fields concerned with cultural processes.

DONALD D. BRAND—*The Date and the Dromedary in Northern Africa*

The numerous errors in recent textbooks treating northern Africa indicate too much reliance on a few secondary sources. Furthermore, these textbooks reflect insufficient acquaintance with the Classics and with the literature in archaeology, history, and economic botany and zoology. For example, it is stated that Moslem Arabs introduced the date and the dromedary into Africa.

The conquering Arabs of the seventh century called southern Tunisia "Land of Dates," where a Roman itinerary shows Ad Palmam. In classic literature we can trace the date-palm in Africa back through Pliny, Strabo, Theophrastus, and Herodotus. The date-palm was common in Egypt and Libyan oases back at least into the Eighteenth Dynasty. Murals showing date gardens, remains of dates, and occurrence of the Egyptian word for date in hieroglyphic texts go back into the Old Kingdom. Apparently even the early Neolithic farmers had the date-palm. There is archaeologic evidence for the date in Egypt earlier than anywhere in Asia. A majority of the authorities consider Africa to be the homeland of the date.

Camels by the thousands were present in northern Africa in Byzantine and Roman times, and they were widespread in the Ptolemaic period. Although the modern camel may have been introduced into Africa by the Assyrians in the seventh century B.C., there is strong archaeologic evidence for the camel in Egypt and the Libyan oases throughout the Pharaonic period and in Pre-dynastic times. In fact, there is earlier archaeologic evidence for the domesticated camel in Africa than in Asia.

JAN O. M. BROEK—*The Ports of Borneo*

Although Borneo is now among the economically more backward parts of "underdeveloped" Southeast Asia it has an interesting history of trade, which can to some extent be

traced through the growth and decline of its former trade centers. This paper deals more specifically with the present situation through a comparative analysis of direction and volume of trade and shipping for all ports of British as well as Indonesian Borneo.

The island is divided into a number of traffic compartments, most of them coterminous with river basins. There are few good natural harbors at economically advantageous spots. Poor accessibility and low level economy have combined to exclude the rise of any primary entrepôt on the island. Singapore, Djakarta, and to some extent Hongkong and Surabaja are the transshipment centers. The main local ports for general cargo are Sandakan, Jesselton, Kuching, Pontianak, Banjermasin and Samarinda. Their hinterlands contain a number of minor ports. A map included in this paper shows the spatial order of areas served by prime (overseas) entrepôts, main and lesser ports. Exceptions to this hierarchic pattern are the few ports specializing in direct shipment of bulky raw materials: Lutong, Balik Papan, and Tarakan for petroleum; Tanjong Mani (also to some extent Sandakan) for lumber. A comparison of the ports, illustrated by maps, gives a measure of the economic differentiation of Borneo's compartments and some indication of the economic potential of this island.

SAMUEL EARL BROWN, JR.—*An Index of Relative Market Area Strength*

One aspect of geography is to determine the degree of inter-regional relationships as reflected in the amount of goods an area of study sells to other areas. This would be simplified if railroads and other carriers made flow data available. Lacking this, the geographer is forced to uncover other sources to reveal these market relationships. Such data might be supplied by individual industries, but the compiler is then faced with the problem of synthesizing these data into one statistical average.

The technique developed here requires industries to reveal the percentage of their sales in various market areas. The percentages for each industry are applied to the number of workers in that industry, revealing the number being supported by sales in each market area. Employee figures for all industries, or a sampling of all industrial types, are totalled to determine the relative market strength of areas for the region under study. The index, expressed in terms of employment, is related to another facet of urban geography, the basic-nonbasic ratio. The technique, which provides a useful substitute for flow data, is illustrated in the Wyoming Valley of Pennsylvania.

HARRY F. BRUBAKER AND DAVID E. CHRISTENSEN—*United States Agricultural Resources for the Future*

The purpose of this paper is to inquire into the potential of agricultural production of the United States. Both food and non-food production are considered. The enormous literature on this subject, including the wide range of United States official estimates, provides a variety of conclusions on agricultural potential. Except perhaps for the most extreme positions, however, the area of agreement is considerable, with many studies differing mainly in emphasis and style rather than content.

The authors regard the agricultural potential as based upon past and present agricultural performance, and attempt prolongation of observable trends. No question is raised about the ability of American agriculture to supply sufficient products for likely population increases at rising levels of living for the next few decades. Several serious problems appear when a long-term view is considered. The paper reviews such problems as the physical adequacy of land and water resources, technological attainments and possibilities, and the capacity for acceptance of, and the propensity for resistance to, the adoption of ideas and practices permitting full attainment of agricultural potentials.

The paper draws some conclusions and raises some questions on all of these matters and indicates the need for additional information to help resolve unanswered questions and to permit more realistic and accurate studies bearing on the problems. The function of geography and geographers is briefly explored.

WILLIAM R. BRUECKHEIMER—*The Steel Warehouse Industry: Its Functional, Distributional, and Marketing Characteristics*

Little has been written about the distribution of steel after it has been produced and especially about the role played by the steel warehouse industry which distributes 20 percent of the nation's finished steel. This paper

has for its purpose an examination of the steel warehouse industry in terms of its functional, distributional, and marketing characteristics.

The nation's steel mills roll to order and, for reasons of economy, handle only quantity orders. The warehouse, therefore, is the only source of steel for many small firms. In addition, the warehouses provide many needed and valuable services to business firms, large as well as small. The foregoing is reflected in the fact that warehouses serve directly over 500,000 customers whereas the steel mills serve less than 50,000.

The distribution of the nation's 2,000 warehouses coincides much more closely with the distribution of the metal working industry than does the distribution of steel mills. A comparison of maps showing these distributions clearly shows that the warehouses can give better and faster service than the steel mills can provide.

Because steel is cheap while freight rates are high, the factor of distance plays a tremendous role in the competitive warehouse industry. Freight rates are particularly significant in determining the boundaries of plant territories for the multi-plant warehouse firm and in determining the size of market areas for potential new plants. The significance of freight rates is clearly illustrated by several maps depicting plant territories and market areas.

MEREDITH F. BURRILL—*Localized Toponymic Generics*

A broken coast line or rough mountainous area in the United States characteristically has one or more toponymic generics (terms in geographic feature names designating the kind of feature) rarely encountered outside that area. Many of the terms are words ordinarily used in a non-topographic sense in American English. Some, particularly those that are not known to occur in any other connotation and are little known in the topographic sense outside the localized region, may be useful additions to our geographic vocabulary.

ROBERT L. CARMIN—*Rapid Growth of Itapací, Brazil—A Frontier Town*

In 1948 the writer studied and mapped the land use of Itapací, Goiás, a Brazilian frontier town. In July 1956 Itapací was restudied. This paper reviews the historical past of Itapací, describes its development during the past eight years, and relates its growth to that of the region.

Founded in 1934, Itapací's physical growth was rapid and by 1948 it had a population over 1000. Its importance as an administrative center increased rapidly also, and in 1945 it replaced the decadent mining town of Pilar as *municipio* (county seat).

The growth of Itapací has been intimately related to the swift expansion of settlement in a greater region of which it is a part. The larger region, a vast section of central Goiás state, has grown in a manner apparently typical of expanding frontiers, namely, by the reciprocal action of land occupance and transportational development. This effect is specifically illustrated by Itapací.

In 1948 the only road to Itapací from the federal highway was a treacherous affair that distinctly limited traffic. The road was poorly surfaced and indirect because the direct route from Anápolis, the nearest railhead city, led through heavy, unsettled forest. By 1953 a more or less solid line of settlement had advanced through the forested zone to and slightly beyond Itapací. With this advance had come a new, more direct, and better road that today offers a more rapid and dependable means of access to regional markets. The new road has provided Itapací with the means for an increased rate of growth—a fact reflected in the town's development between 1953 and 1956.

GEORGE F. CARTER—*The Habitable World: Glacial versus Interglacial*

It is usual to write of the ice age as a time of desolation. It is interesting to examine this notion.

During an ice age a sizeable part of the land surface was covered with ice and arctic climates extended toward the equator. This represented a real loss of habitable earth. During interglacial periods the ice caps melted, more moderate climates prevailed, and large areas of land that were freed from ice became vegetated and available to man. Thus, at first glance, the interglacial times appear to have been more favorable to man.

Glacial effects, however, reached far beyond the ice caps. The wide-scale climatic shifts accompanying the growth of the ice caps turned immense semiarid areas into humid

areas and made much of the desert areas into semiarid areas, or better. These gains were of such magnitude, and in such latitudes, that they were of maximum utility to man. Further, a worldwide 300-foot lowering of the sea level added areas of valuable coastal plain to the area open to human settlement. Such areas in Indonesia and the Gulf of Mexico were so extensive as to have been major gains in useful living space.

The rapid changes over the past 11,000 years have been toward the interglacial world. This has been marked by shrinking utility in the areas surrounding the low latitude dry belt, loss of coastal lowlands, and expanding utility of the high-latitude belts. At the present moment we are in a period of continued rapid change in these directions. Some of the newer climatic theories which see the possibility of the rapid reversal of this condition in the (geologically) near future become then of considerable interest.

CLARK N. CRAIN—*A Geographic Classification of Mass-Wasting*

Growing interest among geologists and engineers in the phenomena of mass-wasting has produced a growing list of attempts to establish a system of classification. These attempts have centered mostly on physical process, ignoring or minimizing resulting forms.

That these forms, especially as they affect the cultural aspects of the landscape, should interest the geographer is obvious. However, classifications primarily based upon process are apt to have little significance to the geographer.

Studies of mass-wasting indicate the possibility of developing a classification that would be useful in geography. Tentatively, this is based upon seven types or groups of contrasting conditions, each inter-related to one or more of the others.

The seven groups proposed are made up of phenomena resulting from:

I. Channeled Movement contrasted with Free Movement
II. High Angle Movement contrasted with Low Angle Movement
III. Rapid Movement contrasted with Slow Movement
IV. Local, Limited Movement contrasted with Widespread, General Movement
V. Dry Movement contrasted with Wet Movement
VI. Slumping Movement contrasted with Sliding Movement
VII. Vertical Heaving contrasted with Vertical Settling

Within each of these groups, geographic characteristics can be recognized for the two contrasting conditions. It has also been possible to evaluate these features in terms of use. For example, problems involved in features resulting from Channeled Movements are much more predictable with regard to desirability of sites than are the problems involving features resulting from Free Movement.

The full classification, together with a list of geographic characteristics, is tentative and subject to revision.

RAYMOND E. CRIST—*The Latifundium: A Neglected Factor in the Evolution of Hill Towns?*

Intensive observation of hill villages in many parts of the Mediterranean Basin have led to the conclusion that a neglected factor in the original *raison d'etre* of many hill villages may have been the latifundium. This powerful force perhaps helped push the people onto hilltops or mountain crests—or helped keep them there once they were there—where they were a labor force available when and as needed. It is an observable fact that latifundia in many sectors include all the fertile low-lying lands. Are they the cause or the effect of the concentration of the population in the hills or mountains?

No attempt is made to speak *ex cathedra* regarding the role of latifundia in determining the sites of hill towns or villages in *all* parts of the world. Other factors were certainly operative in many urban agglomerations, built as refuges from armed enemies or the malarial mosquito, for example. Further, certain hill sites were obviously selected because of the presence of a religious shrine, or because workmen had to live near their work, a marble quarry difficult of access, for instance, or because they were ideal for a military garrison and became march towns, and so on.

Sugar-cane plantations in many tropical countries are forces powerful enough to keep the population in clusters of houses that festoon the rugged hill lands. Thus the latifundium

may, in many instances, be a serviceable explanation of why settlements were originally established on—or remained on—what now seem most unfavorable hillcrest sites.

LUELLA N. DAMBAUGH—*Westward Migration of Coffee in Brazil*

Coffee was introduced into Northern Brazil from French Guiana. It moved east, then south onto the lowlands around Rio de Janeiro and Santos. By the 19th century it appeared in the Paraíba Valley, then spread westward over the interfluves of the Occidental Plateau. It is now penetrating the remaining stands of dense subtropical forests on the western frontier, and being reintroduced under scientific methods in the east.

Reasons for the shifting pattern of coffee culture are primarily inherent in: (1) the nature of *Coffea Arabica,* for it is constantly seeking new soils—*terra roxa legítima*—soils which have 60 percent clay, a pH of 6.5 to 7, and a high humus content; (2) the restlessness of the Paulistas who are always ready to move along in quest of new sources of wealth—land, urban real estate, or industries; and (3) the accelerated world demand for coffee.

Coffee migration has altered the landscape. Forested areas have given way to coffee fazendas, *campo cerrado,* abandonment, or other cash crops of the day (cattle, sugar cane, cotton, citrus, and eucalyptus stands). Sizeable towns are mushrooming on the frontier, while rejuvenation characterizes dormant towns in the east.

The frontier is the realm of the small landholder and where it is possible to climb the agricultural ladder. Colonists from all over Brazil, especially Paulistas, and from several foreign countries, are taking advantage of quick profits.

If coffee is to remain Brazil's major source of income, research must point the way.

GEORGE F. DEASY AND PHYLLIS R. GRIESS—*Some Recent Changes in the Coal Mining Industry of the Bituminous Coal Fields of Pennsylvania and Their Geographical Significance*

The bituminous coal mining industry of Pennsylvania recently has undergone marked changes. The impact of these changes, however, is not equally evident throughout the mining region. Hence, what was once a mining area of relative homogeneity now has become an area of heterogeneity. In essence, western Pennsylvania now possesses *two* coal mining regions with distinctive economies.

The southern region is an area of seriously declining production, derived chiefly from large-scale underground mines. The south, moreover, is an area of low output per miner, of high cost per ton, of high wages and short work-years, of relatively frequent accidents, and of continued dependence upon railroads for movement of coal. In brief, the south retains much of the flavor of the classical coal mining industry of pre-World War II days.

On the other hand, the northern area constitutes what might be termed the "dynamic bituminous coal mining region" of Pennsylvania. Coal output either is holding up relatively well, or is increasing, in the face of declining domestic demands. Mining has shifted significantly from underground to stripping operations. Tonnages per man-day are high, the cost of mining is low, wages are relatively low but underemployment is not chronic, accidents are rare, and trucks are replacing railroads as conveyors of coal. Coal mining in the north today, therefore, bears little resemblance to the classical concept of the industry as it existed in western Pennsylvania during pre-World War II days.

DAVID J. DE LAUBENFELS—*Urban Centers of South Central Chile*

The urban centers of south-central Chile have come into existence only within the last century; in this respect they differ from their nearest neighbors and the majority of Latin American cities. They therefore make an interesting subject for study in the field of urban geography. As sample cases, the largest city, Temuco, and a medium sized town of nine thousand population were studied intensively. Most other urban centers were then visited for comparison. Considerable regional homogeneity was discovered among the various centers. The typical pattern of Spanish American urban organization prevails in spite of their relative youth. Deviations from the traditional pattern that are appearing all over Latin America are well developed here in certain neighborhoods in the larger cities. It is through the abundant availability of wood, which com-

petes here with adobe brick as a building material, that the greatest regional distinction is achieved. Less noticeable are the effects of German landowners and the railroads, both of which have been present almost from the first and have had a constant influence on urban development.

WALTER W. DESHLER—*Overland Transport Costs as a Factor in Development of Areas —A Kenya Case Study*

Communities of the non-Western world may exist for decades in a sort of economic torpor. Obstacles to their development are numerous, interrelated, and complex. One aspect of these cultures which impedes development by limiting the circulation of goods is the high cost of "primitive" transport. The changing overland transport of the northern Kenya coast is an illustration.

This area is occupied by farmer-fishermen who live in coastal villages. They produce grain and dried fish for sale. Market crops are carried from the fields by human porters and donkeys ($1.00 to $1.75 per ton mile) to the coastal villages and then by sailing dhow ($.02 per ton mile) to the larger market towns.

The lands of the coastal strip to a depth of six to eight miles are exhausted. Further inland is a more productive zone but here commercial farming has not been successful.

In 1953-54 grain sold in the coastal villages for about $70 per ton. At the existing high transfer costs even a few miles of transport would take excessively large fractions of the sale price. This has probably been a dominant factor accounting for the overfarming of the coastal strip adjacent to the villages.

In 1953 a dry weather road was built from the south to Kiunga, the major village of the area. The first truck carried grain for $.50 to $.75 per ton mile. With this cost stimulus cultivation patches were cleared and successfully worked in the productive inland zone which had not been accessible previously.

The introduction of truck transport is likely to change significantly the economic prospect of this sector of the northern Kenya coast.

SIGISMOND DER. DIETTRICH—*Resources for the Future—For Whom?*

Any discussion of resources for the future involves certain basic assumptions and inescapable limitations inherent thereto. Resources can be appraised only in their relations to man; therefore the first premise must be the number of people to be considered. Man, however, lives in a cultural environment which delimits the scope of technological advancement; therefore, the second premise must be the cultural and technological development of the people involved. The final question is, how far into the future is the inquiry to be projected?

The basic assumptions concern themselves with the nature of man. First: Man's capacity of learning and understanding is not limited. Second: Indeed, he is far from having exhausted his full capacity of acquiring knowledge and applying it to the use of his resources. Thus, third: Man's understanding and knowledge about resources, advanced as they may be, are not *finite*. Fourth: The present stage of technological development is merely a beginning. Fifth: Technological improvements, though expected to continue, cannot be predicted with any accuracy; therefore, in calculating the man-resource ratio for the future the present conditions of productive technology will have to be taken as a basis.

The scope of the present inquiry will be limited to the United States in space and to the second half of the present century in time. The point of departure will be 1950 at which time there were 150 million people in the country. Assuming that the fertility rate of 1950-53 will continue to 1975, there will be 221½ million inhabitants in the United States in that year. These people will be served by the resources of the land.

Four aspects of the resource pattern were selected for discussion: (1) food, (2) water, (3) power, and (4) minerals. This limited selection was imposed by the arbitrary time alloted for the discussions of the resources for the future.

SIGISMOND DER. DIETTRICH—*The Sugar Economy of the Campos Plain, State of Rio de Janeiro, Brazil*

The plain of Campos is an important sugar producing area of Brazil. It consists of three divisions: (1) along the seacoast the sandy plain of barren soil; (2) the clayey alluvial plain of high fertility; (3) the *tabuleiros* and crystalline hills.

The alluvial plain with its excellent yellow-

clay *massapê* soil is the sugar land *par excellence*. On these soils sugar has been grown since colonial days. The sandy areas are used for stock raising. Along the coast fishing supports a small population. Recently there has been an increasingly rapid beach-resort development.

The fertile *massapê* soil, favorable climate, and the river outlet favored the early growth of sugar culture. In this the Campos plain shared the early economic development of the whole Fluminensen Baixada. The river built up shifting sand bars at its mouth and the great variations in its flow presented serious handicaps to navigation. Therefore, the Campos-Macaé canal was built to be followed by the construction of a railroad. These helped to build up Macaé as the most important port along the eastern coast of the State of Rio.

The economic significance of sugar is paramount in the region. There are 17 large modern usinas which produce 64 percent of the state's sugar. The area is also the chief producer of alcoholic beverages. There is some small-scale farming. The large sugar estates usually keep a herd of cattle on the pastures of the sandy soils. Campos is the urban and industrial center of the area.

ROBERT E. DICKINSON—*The Geography of Commuting: The Case of Western Germany*

Studies of journey to work have concentrated on the range of commuting to and from particular centers. A further problem involves the "regional mobility" of labor, i.e., the degree to which employed persons resident in local communities travel daily to and from places of work that lie beyond their boundaries. Such statistical data are available for every *Land* in Western Germany in the 1950 census. These data indicate for each *Gemeinde* (township) the number of resident workers, of out-commuters, and of in-commuters. From them can be derived a variety of indices indicative of the mobility of labor and their distribution can be mapped throughout the country.

Commuting in the United States is normally by train or automobile, but in the West European countries much greater use is made of public transportation (train and bus) and especially of the bicycle for shorter distances, whereas use of the automobile is negligible. Moreover, commuters are of two types—allochthonous commuters, who work in a city but live in the suburbs beyond its boundaries; and autochthonous commuters, who are native to the countryside and continue to live there, though traveling daily to work in village, town, or city. The latter are especially characteristic in many European areas. In such areas, the intensity of movement depends not merely on the accessibility of a big city center, but also on the prevalence of such conditions as large families, inadequate land holdings, and agricultural underemployment.

A map of Western Germany will be presented on which the mobility of labor is shown by the ratio of out-commuters to the number of resident workers in each *Gemeinde*. From the general patterns so revealed, several areas will be selected for special comment—viz., the Palatinate, north Württemberg, Rhineland-Westphalia, and Braunschweig-Salzgitter-Wolfsburg.

STANLEY D. DODGE—*Distribution of Population in the Old Northwest in the First Half of the Nineteenth Century*

The patterns of settlement developed in the Old Northwest before the coming of the railroad depended on trails, roads, and canals, which connected the settlers directly or indirectly with the older eastern towns and villages. In the first half of the 19th century all the land making up the Old Northwest had been settled, except for the northern part. The advance of the American people into the area had begun before the beginning of the century, when most of southern Ohio, much of southern Indiana, and some of southern Illinois were occupied by backwoodsmen. Outposts for the "attack" on the Old Northwest had been established at Buffalo, Pittsburgh, and in the newly formed towns in Kentucky in the last fifty years of the 18th century. All were at the end of roads leading back to the older area of settlement along the Atlantic seaboard. From the outposts, but especially from Pittsburgh, the produce of the frontier was exported. By the middle of the 19th century, settlements had spread over all the territory, except the northern parts of Michigan and Wisconsin.

An isochronic map of settlements suggests the importance of "roads" in the process of settlement. One such road is Harmar's Road in western Ohio. Along it forts had been built

in the 1790's as far north from Cincinnati as Defiance, Ohio, and Fort Wayne, Indiana; and about the forts hunters, fur-traders, and a few backwoods farmers were already beginning to congregate.

The importance of the roads "back east" in the development of the territory is indicated by the large extent of land, nearly half, which was settled in the period 1820 to 1840, that is, after the opening of the Erie Canal. Significant changes in the distribution of population, resulting from the opening of the Erie Canal, may be seen in the "behavior" of population curves. The correlation of population curves, by means of indices of what may be called the "second derivative," show already the beginnings of new patterns at Buffalo and Pittsburgh in 1820, and at Cincinnati within the Old Northwest. By 1830 significant developments were beginning at Detroit and Cleveland, and by 1840 at St. Louis and at Cincinnati for a second time. In 1850, at the end of the period, two important areas of development were western Ohio and central Illinois, partly owing to the opening of the Maumee-Wabash Canal in 1848, but by then railroads were beginning to bring the older patterns of settlement to an end. Though the coming of the railroads altered everything, the basic pattern, the one originally established, has never been wholly obliterated.

KEITH E. DUKE—*East versus West in Burma*

The modern state of Burma came into existence in January 1948 as the first British possession since the American colonies to break completely and decisively the political ties which bound them to a European colonial power. Largely without trained autochthonous leadership and with little outside aid, Burma has been faced with tremendous problems of internal development, problems which have been further complicated by international tensions in Southeast Asia.

Predominantly Buddhist in culture, Burma has strongly advocated a neutralist policy similar to that of India. Yet, the world-wide struggle between East and West has come to Burma in many ways. Armed forces of both the Nationalist and Communist Chinese governments have invaded Burmese territory, and dissident Burmese partisans on both sides have kept the East-West struggle alive inside the country. Economic development of Burma's rich mineral and forest resources has been hindered by the lack of internal security outside the populous rice-rich river valleys. As a consequence, Burma has been forced into a policy of cultivating rice for sale in foreign markets as almost the only means of obtaining credits necessary to establish schools, build up industries, revamp outmoded transportation systems, and conquer pestilence and disease.

Latterly, Burma has been faced with a well-planned economic offensive on the part of the U.S.S.R. which the Western world is trying to combat with an extensive economic aid program of its own. In an attempt to remain neutralist, the Burmese economy has suffered. Today, an attempt at playing both sides against the middle while accepting help from each is proving both dangerous and costly. The meeting of East and West on the neutralist grounds of Burma remains a continuing problem the outcome of which might have reverberations all over the world.

ARLIN D. FENTEM—*Trade, Transportation, and Agriculture in the Old Northwest, 1840-60*

To a greater extent and at earlier stages than is often realized, frontier economies in North America were oriented toward extra-regional markets. In the Old Northwest, areal specialization in agriculture was present from the very outset and had become as marked at the time of the first agricultural census as it is today. At that time adjustments of land use to physical conditions were even more apparent than now. This fact reflected the relative abundance of land and scarcity of capital for modifying its natural conditions, the marginal nature of competitive production for distant markets, and the limited range of choice in crops and animals available to the western farmer.

The period 1840-60 was one of rapid change for this region. New domestic markets for agricultural products developed; newly settled lands beyond the Mississippi arose to challenge established supply areas; foreign consumers shifted in importance in response to changing economic policies; new transportation media were adopted as others fell into relative disuse. All these developments were accompanied by concomitant areal changes in agriculture. Maps of agricultural distributions, flow charts, and

cartographic analyses of market area strengths accompany the paper. They are designed to demonstrate the prime roles of transportation facilities and market orientations in explaining the changing agricultural geography of the Old Northwest in the two decades preceding the Civil War.

MARJORIE SMITH GOODMAN—*A New Look at the World's Population Problems*

Geographers must take a new look at the population problems of the world. The medium for this new look is a map of population density per unit of national money income.

We commonly measure population density per square mile of total land. Frequently we employ tables of population density per square mile of cultivated land. The latter strike closer to the heart of population problems than the former, but some of the suggestions are nonetheless misleading. Recent tables indicate, for example, that Japan's problem is twice as acute as that of China.

Cultivated land is only one of a country's agents of production. To appraise population problems definitively, we must consider the total production of nations.

Economists use national money income as an index of total production. Recent United Nations publications list such income statistics for seventy of the world's nations. When converted to a common currency and analyzed in conjunction with national population figures, the statistics give startling population concepts.

The map of population density per unit of national money income is a more definitive representation of the world's population problems than are maps and tables now employed by geographers. The new medium corrects numerous misconceptions. By this map, for example, the scale of Japan's problem is approximately one-fourth rather than double that of China.

ROBERT J. GOODMAN—*Criticism of Visual Aids as Employed at Our National Meetings*

So-called "visual aids" commonly are neither visual nor an aid in illustrating a point of a geographic paper. Before a slide can be an aid it must first be legible. Legibility, essentially a problem in scale, can be achieved through simple and effective techniques. Impact depends upon a careful planning of the layout and the judicious use of color.

The meticulously typed but completely undecipherable statistical tables must go. They can be replaced with tables that are excitingly lucid. If there is a special point of significance on a slide, then it should be emphasized to bring it out. New tools such as multi-colored plastic tapes and velva-glo papers are now available to make our slides more effective.

Standards must be set for visual presentation. Such standards can best be examined, discussed, tested, and accepted through demonstration at our national meetings.

THOMAS M. GRIFFITHS—*Role of a Retreating Ice Margin in the Formation of Glacial Features*

Study of the margins of the Greenland Ice Cap during the past three years has brought to light a number of unique phenomena. Among these are shear moraines, marginal protection, ice cliffs, marginal streams, and ice-dammed lakes.

It is suggested that these phenomena can serve as keys to many features of the continental glaciated landscape.

Continental glacial features can be classified into three broad categories. (1) Features resulting from ice sculpturing: e.g., scoured basins. (2) Depositional features: e.g., moraines. (3) Glacial-aqueous features: e.g., outwash terraces.

The landforms associated with each of these categories have been molded by their mode of origin. However, morphology is seldom used as a criteria of classification. In the case of sculptured features, the shape or physical characteristics are the basis of classification. In the case of depositional and glacial-aqueous features, the physical nature of the materials composing the feature—till or outwash—is the primary determinant.

Concern over taxonomy has sometimes obscured the dynamic nature of glacial activity. In its retreat toward impending death, the ice margin is drawn inward, as it were, over all of the area once covered by the ice.

Features resulting from ice margin activity are numerous and most likely to survive, since they result from the latest glacial activities to affect any given deglaciated location.

The marginal features and phenomena

which are being examined in Greenland today seem to provide a logical guide to the morphology of the continental glaciated landscape.

NATHANIEL B. GUYOL—*U. S. Energy Resources for the Future*

Our energy supplies in 1975 will be determined by the trade policies we adopt and the prices we are willing and able to pay for energy, not by the quantities of coal, oil, natural gas, and uranium that underlie this country. We can, if necessary, meet all our energy requirements during the next twenty years from our own resources—if not by extraction, then by conversion of fuels from one form to another, by substitution of one energy source for another, or by substitution of one pattern of activity for another. This self-sufficiency is significant, however, only to the extent that it enables us to obtain energy at lower cost than it could otherwise be obtained. With the development of low-cost energy supplies outside this country, especially in the Middle East, and with the development of low-cost means of energy transportation, such as the super-tanker and the large-diameter pipeline, the significance of our own resources has already diminished. It will diminish further as production costs in this country increase, relative to production costs elsewhere in the world.

During the past two decades, consumption of fuel and power in the United States has risen at an average rate (compounded) of 3½ percent per annum. In the year 1955, total consumption of fuel and power in the United States amounted to the equivalent of 1.4 billion tons of coal—roughly 40 percent of all the energy consumed in the world in that year.

Unless the expansion of the U. S. economy is interrupted by major catastrophes, such as wars or serious economic setbacks, our energy requirements should continue developing at a rate of about 3½ percent per annum, thereby attaining twice their present level, or the equivalent of 2.8 billion tons of coal, in 1975. Aggregate requirements during the period 1955-75 should be on the order of 40 billion tons coal equivalent. To meet these requirements, we will need about 10 billion tons of coal, 80 billion barrels of liquid fuels, 300 trillion cubic feet of natural gas, and perhaps 5 trillion KWH of hydro or nuclear electricity.[1]

[1] All data preliminary.

ELEANOR E. HANLON—*Geography's Role in Community Watershed Planning*

There are today more than a thousand small watershed associations, or similar groups, widely distributed throughout the country. There are some 15,000 still to be formed. Each is dedicated to the concept that healthy community development, based upon wise utilization, management, and conservation of our soil, water, forest, and related resources can best be effected within the framework of the natural unit: the small watershed. The latter is a stream drainage area of a few thousand to several hundred thousand acres, where all the people have a community of interests and problems.

Geography has a real challenge and a unique role to play in this community watershed planning movement. For the facts of local geography, the relationships between the land and human occupance, the basic maps depicting these elements and their interrelationships are urgently needed and rarely available.

This paper is an example, from an actual program begun in 1955 and still in progress, of the important role geographers may play in community watershed planning. It is a summary of the work being done by a team of geographers for the Limestone Creek Watershed Association, Onondaga County, New York. It includes the large-scale maps, results of interviews, and the methods used in presenting the geography of the watershed to the local people. It concludes with suggestions for participation by geographers in all phases of the small watershed planning and development program.

JOHN FRASER HART—*Farmsteads and Types of Farming in Britain*

Despite a paucity of objective evidence, geographers commonly assume that types of farming areas are reflected in many other aspects of the rural landscape. This hypothesis was tested in Britain by an attempt to determine whether distinctive types of farmsteads are found in different types of farming areas. It was discovered that the apparently complex British farmstead is actually a collection of modular functional units. One modular functional unit, the barn complex, is discussed in detail to illustrate the nature of the concept. It is shown that the barn complex is closely related to grain farming and stock feeding.

Other modular functional units are associated equally closely with other phases of farm operations.

It is concluded that the farmstead is closely related to the operation of the farm, but three factors preclude definitive statement of the relation between types of farmsteads and types of farming areas in Britain: (1) there have been changes in types of farming since the original construction of farm buildings; (2) of necessity, any type of farming area is a generalization, and includes different types of farm operations; (3) types of farming areas in Britain are delimited by distinctions too fine to have significant effect on the visible agricultural scene. If types of farming were delimited on a grosser base, and exceptional farms ignored, there might indeed be a relationship between farmsteads and types of farming in Britain.

JOHN FRASER HART—*Value Systems and Geographic Research*

The study of value systems, as a key to understanding cultures, is an essential element of cultural geography. Such study also has important ramifications for research in the broader field of human geography, but all too often geographers have followed the lead of classical economists in equating price and value. It is unsound to assume that human decisions are based solely on monetary considerations, and that decisions based on other considerations are "economic anomalies." Many human decisions of considerable geographic significance are greatly influenced, if not determined, by value judgments in which price is at best a minor element. Instances cited include the introduction of beef cattle into the American Southeast, population migration from the Southern Appalachians, and fox hunting in Britain.

Geographers need give greater consideration to the value systems of regions. Comprehension of the regional value system is essential to an understanding of the region. More intensive research should enable geographers to establish generic principles concerning the areal variations and relations of value systems. The development of such generic principles would increase the stature of geography as a social science.

LESLIE HEWES—*Wheat Failure in Nebraska: Trends, Causes, and Implications*

Dry farming, the chief economic support of the Central Great Plains, has the reputation of involving high risks. Wheat failure is probably the best indicator of such risk. Since 1937 there has been notable reduction of the high failure which marked the period 1931–37.

In most of western Nebraska, failure in the latter period has been reduced by 20 percentage points or more, commonly by more than half. The first cause suggested is improved weather. However, *dry autumns*, which appear to have been the greatest weather hazard, have been ameliorated in only a portion of the area. Elsewhere, at least, other causes for reduction in wheat failure must be sought. Available data indicate *summer fallowing* as the chief cause in at least four panhandle counties. In remaining areas, *other causes* are most important. Probably included are reduced grasshopper damage, less wind damage, less heat in early summer, better seed, and improved methods and *know-how*. It is unlikely that new varieties of wheat have been an important factor, and the decrease in failure has taken place despite increased hail damage and, locally, wheat mosaic.

Whereas the chief cause of wheat failure was formerly drought, hail has more recently been the chief cause of failure in most of western Nebraska.

Implications for the future of the region are to be found in the considerable reduction of risk due to summer fallowing and other cultural improvements. Further investigation should show whether other parts of the Central Great Plains have fared similarly.

GEORGE M. HOWE—*Climatic Regions Delineated by Climatic Criteria*

Regional classification of climates need not depend upon reduction of all the variety of day-by-day weather conditions to "static" average weather represented by arithmetic means nor upon application of non-climatic criteria to differentiate among climates. Accepting the broad definition that climate is "a summary of weather," an appropriate statistical measure of climate is the frequency distribution, which can be expressed in a form suitable for regionalization; also, all weather elements which together comprise the state of

the weather should be included as agents of classification. Recognizing that within any climatic region a range of characteristics will exist, regions based upon climatic criteria alone should contain relative constancy of difference between climate characteristics at any two places equally distant within a given region.

Isopleths of percentage frequencies of seven weather elements for the North Atlantic in February and August exhibited close correspondence in location of changes of gradient strength and direction. By delineating regions for each month at these changes of gradient, each region consists of a core with specific percentage frequency of weather conditions surrounded by relatively constant gradation of each weather element. Each region, it is shown, experiences relative homogeneity in the weather patterns and sequences which the percentage frequencies summarize.

A similar technique of regional climatic classification could be developed for land areas. Some modification or extension would be required to create a classification comprising the annual climate. Statistical manipulation could provide an objective basis for regionalization.

HILDEGARD BINDER JOHNSON—*Early Spatial Relationship of the Old Northwest*

After a short discussion of the use of the term "northwest" in American geography, the factors which contributed to the neglect by the French of at least the eastern half of the Old Northwest are evaluated in an expository treatment. The wealth of historical literature which brings nongeographic factors into full play fortunately prevents a deterministic approach. A classification of geographic factors will focus attention on area relationships rather than on the complexity of historical personalities, events, and available sources.

Significant in the physical geography of New France were—among others—the rapids of the Upper St. Lawrence, the canoe route via the Ottawa River, the site of Grand Portage, the difference between upstream and downstream travel on the Ohio and Mississippi, climatic conditions—particularly for the route to Hudson Bay.

The Iroquois League, the shifting location of Indian tribes, French and English traditionalism in meeting transportation needs, New France's inability to compete with (cheaper and better) British goods, the early failure of establishing a supply line via Lake Erie, the quality and distribution of French settlers, and competing promotion of food producing settlements and mining enterprises are some aspects of the human geography of New France.

The basic objective of French expansion during the 17th century was the discovery of a Northwest passage. Old maps—mostly from the James Ford Bell Collection—reflect cartographically the by-passing of the Old Northwest by the French. De la Gallisonniere's *Memoir on the French Colonies of North America* (December 1750) clarifies the main objective of the 18th century, the maintenance of the connection between Canada and Louisiana.

FERENCZ P. KALLAY —*Sardinia's Population Problem*

Overpopulation is one of the major problems of the world today. Underpopulation is rare and is found in relatively remote areas, such as the Americas and Australia.

The island of Sardinia is one of the few European examples of an underpopulated area, having a population of little more than half of what it was under Roman domination. Sardinia was originally developed by the Romans as a naval station and a wheat producing region. When Rome conquered Egypt, the latter became the principal grain producer of the Empire, diminishing Sardinia's importance as a source of grain. Its strategic importance as a naval base decreased with the rise of Sicily as a Roman stepping stone to Africa. The most important cause of population decline, however, was malaria, which infected the lowland regions. As a result of poor sanitary conditions and the distance separating Sardinia from mainland Italy, the island became almost completely isolated from the political and economic life of Italy.

Since the eradication of malaria (1946–51) a substantial increase in cultivated land is expected within the next decade. Through the Italian "bonification" program the newly created small farms are receiving technical guidance and financial assistance from government resettlement agencies.

On the basis of a detailed analysis of physical, agronomical, and cultural factors governing the use of Sardinia's land, potentially good

crop areas now in pasture can be reclaimed. Future emphasis should be on grains, horticulture and citrus fruit, as well as further development of such existing cash crops as olives and cork.

Sardinia's low population contrasts markedly with Italy's high population. It is reasonable to ask, therefore, whether conditions in Sardinia can be modified to bring about mutual benefits for Italy and Sardinia, not only to provide an outlet for some of Italy's surplus population, but also to bring about a general rise in living standards and agricultural productivity in Sardinia.

P. PRASAD KARAN—*Locational Pattern of the New Centers of the Indian Iron and Steel Industry*

During the last two years considerable attention has been focussed on establishing state-owned steel works in India. Three new integrated steel works, each having one-million ton capacity, will be completed by 1960 at Bhilai, Madhya Pradesh, Rourkela, Orissa, and Durgapur, West Bengal, and proposal for a fourth at Barakar, Bihar, has been made. The Bhilai plant is the first major project outside the Communist Bloc to be financially aided and built by the Soviet Union. The Rourkela and Durgapur plants are being erected respectively by the German and British firms.

The basic locational pattern of the steel works largely reflects the pull of coking coal and iron ore deposits of northeast India. The Bhilai plant will use the Bokaro coking coal and the adjacent unexploited iron ore near Dalli and limestone at Deorjhal; the nearby Korba coal field is being developed to supply thermal power. The Rourkela plant is located adjacent to the Bihar-Crissa Iron Belt and will obtain coking coal from the Bokaro field. The siting of the Bhilai and Rourkela plants away from Damodar coking coal fields reflects partly the emphasis placed by the Indian planners on the industrial development of the so-called "backward" states — Madhya Pradesh and Orissa. The Durgapur plant has the advantage of location near one of the principal steel markets—the Hooghly-side industrial strip of Calcutta, Bihar-Crissa iron and Damodar coal, while the river Hooghly would ensure both adequate water supply and cheap transportation. The proposed plant at Bokaro in Damodar valley will be based on local coal and Bihar-Orissa iron ore resources.

HIBBERD V. B. KLINE, JR.—*The Banana Islands of Sierra Leone: A Study in Geographical Conservatism*

The offshore islands of tropical Africa had high geographical significance from the 16th into the 19th century. From these bases, relatively secure from disease and from attack, operated alien traders and slavers. In this century a few of these islands still play important roles, but many have been almost forgotten. Among the latter are the Banana Islands off the Sierra Leone peninsula. The negative character of development there and the cultural conservatism of the people have preserved landscapes and ways of life until today that were typical of comparable mainland settlements a century ago.

The historical geography of the Banana Islands falls into three periods. The first was replete with rival native chieftains, slaves, slavers, pirates, and warships. The period ended abruptly in 1820 when, by treaty, the British flag began to fly over them. In the second period, Creoles, that is to say liberated Africans, came from the mainland and under missionary tutelage founded the villages of Dublin and Ricketts. These settlements blended Victorian English and indigenous West African ideas of the proper settlement patterns, structures and functions, and they duplicated the mainland Creole villages established under the same auspices. In the third and present period the mainland villages have gained many of the amenities of the 20th century, but the Banana Islands remain almost undisturbed by modern technology. Therefore, Dublin and Ricketts offer the contemporary geographer a look into the past of some dozen Creole settlements.

CLYDE F. KOHN—*Spatial Patterns of Suburban Commercial Retail Services: Part I, the Problem and Present Shopping Habits*

There appears to be a radical reordering of the spatial patterns of commercial retail services within the urbanized areas of our country. Recent studies provide valuable insights concerning the impact of new outlying regional centers on downtown central business districts, but so far none have demonstrated their effects on nearby *suburban* centers of long standing.

An opportunity to complete such a study was afforded by the recent development of "Old Orchard," a suburban regional shopping center in Skokie, Illinois, located within the present trading area of Evanston's central business district, also a major shopping center, and five miles from it.

Data were collected by means of telephone interviews. Respondents, selected on a random sample basis, were asked to name the shopping center in which they last purchased nine major items and last bought three kinds of professional services. Analysis of the data collected shows that Evanston's central business district ranks low as a center for the sale of jewelry and major appliances, but relatively high for women's clothing, men's furnishings, and street shoes. The Chicago Loop is its strongest competitor. In all, respondents identified 46 specific shopping centers within the Chicago Metropolitan Area in which they had made their last purchase of at least one of the items included in the survey. The study supports the generalizations that the drawing powers of a suburban shopping center vary (1) with each of the services it renders; (2) with distance outward from its core; (3) with the quality and quantity of merchandise handled by merchants in nearby shopping centers, and (4) with ease of accessibility by automobile and public transit.

HUEY LOUIS KOSTANICK—*Eastern Europe—Coveted Crossroads*

"Fracture zone" and "transit land" are terms commonly used to characterize Eastern Europe. They apply equally well today as they have historically. Although the protagonists have shifted, the tensions created by foreign control and the value of the area to foreign powers reflect the same critical patterns of former years.

The brutal methods used to end the Hungarian revolt in late 1956 show the extent to which the USSR will go to maintain hegemony. For the Russians, Eastern Europe is a crucial region. It is the first non-Soviet area wherein Communist governments have secured full control—thus it is a philosophical symbol of the expansion of Communism. Then, too, it has prime value as a source of agricultural crops; manufactured goods; critical minerals, as uranium; and accessory complements such as manpower and industrial skills. But perhaps most significant of all is its strategic value. Eastern Europe controls all landward access between the USSR and Western Europe. No less does it represent control of the Baltic and Mediterranean exits of the Russians who have expanded politically westward to the Elbe.

Communist control has induced internal population resistance and hatred. Popular antipathy, stemming from economic as well as political reasons, is directed both against the Russians and against Communism. Such internal dissension plus the over-all conflict of East and West will continue to make Eastern Europe a "tension area," perhaps the most critical in the world.

ANNEMARIE KRAUSE—*The Occurrence of Frost in the Paraguayan Segment of the Aw Climate*

To most of us frost in a segment of the Aw climate is an anomaly. Are not the average temperatures of the coolest month more than 18° C. (64.4° F.)? However, these averages are most deceptive and misleading, for included in them are temperatures that approach and fall below 0° C.

An example of an Aw climate area where frost occurs is the northern Chaco of Paraguay, between the Pilamayo River on the southwest and the Paraguay River on the east. Data are based on records of the following stations: Mission Inglesa in the southwest, the Fortín Mariscal Estigarribia in the west, and Colonia Menno, the oldest of the Mennonite settlements in the Chaco where the writer collected data for a thesis titled "Mennonite Settlement in the Paraguayan Chaco."

The data for each of the stations satisfy the coolest-month temperature averages for the Aw climates. Yet each station has recorded frost as early as May and as late as September. Mariscal Estigarribia from 1940 to 1949 experienced 0° C. or below 19 times, and at 26 other times the mercury dropped to 2° C. (34.5° F.). In Colonia Menno temperatures of 0° C. or below are on record during more than half of the 25 years. An all-time minimum for the area of –7° C. (19° F.) occurred in July, 1955.

Man faces the dilemma of primary adjustments to tropical temperatures in the face of recurring frosts.

JAMES F. LAHEY—*Causes of Limited Rainfall Along the Northern Coast of South America*

The northern South American coast is distinctively arid. Seasonal wind fields at six levels indicate strong horizontal divergence at low levels and convergence at higher levels indicating strong subsidence during most of the year. The suggested causal mechanism for this subsidence is a large contrast in transverse wind stress in the trade stream due to land-water orientation relative to the trades. This contrast in wind stress leads to a dissipation of weak to moderately strong easterly waves as they pass across the coastal area. Only deep easterly trough systems associated with westerly troughs farther north can cause extensive rainfalls over this dry area.

PHILIP B. LARIMORE, JR.—*Cartographic Techniques Used in the Reconstruction of Louisiana's 1812 Historic Shoreline*

The Coastal Studies Institute, Louisiana State University, has constructed a map delineating the Louisiana shoreline of 1812, when the state joined the Union. First planimetric surveys of this area were made in 1853, prior to which only sailing charts and reconnaissance maps were in existence. Since 1853 many detailed surveys have been made and were incorporated into this study. Studies in deltaic and coastal regions indicate that processes of erosion or accretion follow recognizable patterns. Consequently a graphic method was used to reconstruct this shoreline.

Fifty-two detailed base maps (1/20,000) covering coastal Louisiana were prepared and shorelines from all accurate surveys, ground and photogrametric, transferred to them. Perpendiculars were constructed on the base maps at points one statute mile apart along the entire shoreline. For each point a graph was prepared using years for the abscissa and miles for the ordinate. At each station, points indicating the shoreline position for the successive dates of the several surveys were plotted on the graph. A straight line of best fit, drawn through these points, was extrapolated to the year 1812 and this calculated position then transferred to the base maps. A total of 351 graphs were prepared and the shoreline reconstructed by connecting these points. All data were then transferred to a single map, scale 1/250,000.

It is felt that this arbitrary technique, tempered with the investigator's intimate geologic and geomorphic knowledge of the area, produced as accurate a map as is obtainable.

GEORGE K. LEWIS—*Rural Slums*

The term *slum* has been used traditionally to describe an urban phenomenon. There are, however, many rural settlements in the United States that possess both the physical and cultural characteristics of urban slums—close crowding of buildings, substandard living conditions, low income level, etc.

An area of one thousand square miles in eastern Massachusetts serves as a sample for this study. This is, for the most part, a rural section with several large metropolitan concentrations nearby—Boston, Providence, and Worcester. Nearly one hundred rural slums are located within the sample area, ranging in size from a score of dwellings to several hundred.

Two-thirds of these depressed settlements are located on pond margins or along rivers. The remainder are found on a variety of sites but favor level areas, particularly kame plains and other outwash features.

Many of these slums are composed of summer camps that were converted to year-round use during the depression of the 1930's. Few of these dwelling units were suitable for permanent occupancy. Other rural slums developed on land that was worthless for farming or lumbering.

The presence of one or more rural slums in a town often creates serious problems for the local government. World War II and postwar prosperity have done much to improve these areas, but the basic characteristics of the rural slum prevail.

J. ROSS MACKAY—*Structural Features formed by Glacier Ice at Nicholson Peninsula and Herschel Island, N.W.T., Canada*

Nicholson Peninsula and Herschel Island contrast with the adjacent areas of the low undisturbed sediments of the Arctic Coastal Plain in being considerably higher and in having deformed sediments. The deformed zones are at least five miles long and up to five miles wide. The thickness of sediments involved exceeds 100 feet. Deformation by glacier ice can take place in at least three ways: by the

pressure of ice against a topographic obstruction; by the drag effect of ice over subjacent material; and by the incorporation of englacial material which, upon the melting of interstitial ice, becomes "fossil hard parts." The greater altitude and structural features of Nicholson Peninsula and Herschel Island have probably been caused by the pressure of glacier ice against topographic obstructions transverse to its movement or the drag effect of the ice; that is, the two areas are large push moraines.

Although permafrost now lies within several feet of the surface in both areas, it is not known whether the sediments were frozen or unfrozen when they were deformed. Shear planes exhibit a high degree of polish due to remoulding of clay particles; since such remoulding can take place when clay is unfrozen, but might not when the clay is frozen, there is slight evidence to suggest that the sediments were unfrozen at the time of deformation. If so, the sediments may have been submerged; or, possibly, since clay may remain plastic at below freezing temperatures, deformation may have taken place under such conditions.

CURTIS A. MANCHESTER, JR.—*Expansion of Kona Coffee Production in Hawaii*

Experimental planting of coffee in the Hawaiian Islands dates from 1813. The industry expanded and since 1845 coffee has been a regular export. However, with the collapse of coffee prices in the nineteen twenties, the plantations and farms on the other islands were turned to other crops or abandoned and the acreage on Hawaii was greatly reduced.

The current high price of coffee has rejuvenated coffee growing in the Kona district of the island of Hawaii. Present coffee prices permit wages of eight dollars a day for hired labor in contrast to wages as low as thirty dollars a month in the nineteen thirties and finance the use of machinery and other labor-saving devices.

In Kona, where ideal physical conditions for coffee growing are found at elevations between 700 and 2,000 feet, new areas are being planted, and abandoned coffee orchards, sometimes with trees seventy years old, are being recovered. High profits and mechanization resulted in a doubling of the acreage between 1950 and 1956.

On new farms bulldozers quickly and cheaply remove heavy vegetation and rocks. Formerly the rocks were broken with sledge hammers and crowbars. Trees are spaced to allow passage of jeeps hauling coffee beans, carrying fertilizer, and bringing chemicals to fight weeds and pests.

The modern coffee farmer is a businessman who is aware of the possibility of another slump in coffee prices. To prepare for lower prices he is making maximum use of scientific information and machinery and minimum use of manual labor.

CHARLES BARRON MCINTOSH—*New Zealand Surface Winds: Characteristics and Regional Variation*

Maps of surface winds in New Zealand have not been available for climatic analyses. New wind maps for the months of January, April, July, and October are presented here as a further step toward a more complete understanding of the dissected climates of New Zealand.

New Zealand is under the zonal influence of westerly winds; and local winds exhibit definite patterns and seasonal variations resulting from zonal winds. On the other hand, the new wind maps reveal a multiplicity of wind patterns produced by major controls other than the zonal winds. The extremely varied character of winds throughout New Zealand can be accounted for primarily by the diverse physiography found in those southern hemisphere islands. The basin-mountain region of Central Otage and the plain-to-mountain cross section of Canterbury are used to illustrate the part landforms play in regulating the direction of air movement.

Because stations with similar physiographic exposure have similar wind characteristics, it has been possible to construct a *regional wind map*. Regionalization of wind patterns in this map is more distinct on South Island than on North Island because South Island has (1) greater linear continuity in landforms throughout its length and (2) better distribution of wind recording stations in relation to landform distribution. The regional map of winds, when compared with maps outlining climates of New Zealand, emphasizes the importance of air flow in determining regional characteristics of climate.

TOM L. MCKNIGHT—*Feral Burros in the American Southwest*

One of the most interesting members of the exotic fauna of the United States is the feral burro of the Southwest. Introduced as a draft animal to this continent from Spain and North Africa by the "conquistadores," the domesticated burro was well-suited to life in arid and semiarid lands. When set free by accident or design the hardy jackass quickly became adapted to a feral existence.

Today wild burros are found in parts of nine western states. Most numerous in Arizona, southern Nevada, and southeastern California, burros also inhabit northeastern California, southeastern Oregon, northern Nevada, various portions of Utah and New Mexico, western Colorado, southwestern Wyoming, and the Big Bend country of Texas. The total number of feral burros in the United States is estimated to be between 7,000 and 12,000. Though conclusive statistics are nonexistent, it is considered that this represents a considerable decline from the burro population of two or three decades ago, due largely to systematic shooting in certain areas.

Because they furnish serious competition in terms of forage and water for certain species of indigenous fauna, wild burros are frequently persecuted, though they find staunch defenders in various humane organizations and interested individuals throughout the West. However, for better or for worse, the wild burro is now a definite part of our southwestern fauna. Its ability to prosper under environmental conditions that are more or less untenable for most other quadrupeds makes the possibility of economic use of its adaptability and hardiness worthy of much greater exploitation.

ROBERT B. MCNEE—*Socony Mobil: An Exploratory Case Study of Selected Geographic Patterns of an Oil Corporation*

This study illuminates the functional geography of the oil industry through a new approach, *corporation geography*. A corporation region is a planned economic region, focal in character. Geographic study of corporation regions clarifies the functional interrelationships of an industry and makes possible cartographic comparison of differing corporations within a single industry or among varied industries. This study is exploratory since corporation geography has not been cultivated.

Such study is important to petroleum geography. An oil company region frequently embraces the globe. The major companies usually include all four functions (production, transportation, refining, and marketing), integrated to varying degrees. Seven oil companies dominate international petroleum; seven regional systems include most of international oil geography. Each corporation region is largely autonomous, but this autonomy is modified by interrelationships among corporate regional systems, as in joint operations.

Socony Mobil Oil Company, Inc., with affiliates, is one of the seven international giants; it is most representative of this group, in size, functional integration, and geographic diversification. Five selected geographic patterns are examined: (1) Historical development of the Socony Mobil regional system, (2) producing patterns, (3) refining patterns, (4) marketing patterns, and (5) product flow and transportation. Each is analyzed with appropriate world maps and compared with related patterns of the whole world oil industry. The functional patterns of Socony Mobil are then analyzed comparatively. The study concludes with observations on the significance of the Socony Mobil regional system for world petroleum geography. The author studied Socony Mobil directly through an industrial fellowship.

DONALD W. MEINIG—*Three American Northwests: Some Perspectives in Historical Geography*

An overview of three "Northwests" from two separate perspectives is suggestive of important avenues of research for historical geography.

In terms of spatial content, the Old Northwest may be viewed as the culture hearth of the main stream of American rural tradition. Elements from the cultural variety of the Seaboard were here blended into a distinctive complex which was carried westward with modifications onto the High Plains. Colonization of the Pacific Northwest paralleled in pattern and process that of the New Northwest (Upper Mississippi-Dakota). Emigrants were drawn principally from the Old Northwest, the Willamette served as the local culture hearth, and expansion eastward into the Colum-

bia grasslands paralleled that into the Northern Plains. Other historic agricultural complexes in the United States are either different in origin or divergent in development from this dominant pattern.

In terms of spatial concepts, these Northwests reveal great variety. Because of an overlay of discordant occupance patterns, "Old Northwest" never took root as a popular regional concept. Migrating westward with settlement, "Northwest" became stabilized in the Minnesota-Dakota area, persisting as an approximation of the Twin Cities nodal region. "Pacific Northwest," popularized by Portland commercial interests, became firmly established in both popular and professional thinking.

Popular spatial concepts deserve greater attention. They may provide clues to historic variations in physical environment, to relevant areal units of past times, to developing multiregional images of the public, and to fresh views of important spatial organizations. A historical human geography which includes both spatial content and concepts can make important contributions to the interdisciplinary study of regional consciousness.

Three main categories of the history of ideas are of direct significance to historical geography: (1) the developing knowledge of the physical patterns of the land, (2) the growth of understanding of the qualities of the environment, and (3) the history of spatial concepts related to meaningful areal divisions. The first two have received some attention from geographers but the last needs more emphasis and its study provides new insights for the historical geographer.

ALEXANDER MELAMID—*The Geography of World Petroleum Prices and the Middle East*

Over 6,000 firms compete in the United States petroleum market whose center is in Tulsa, Oklahoma. Nowhere else in the world is there a similarly active market, and Tulsa prices therefore determine world petroleum prices. Until 1949 freight (pipeline, tanker, etc.,) was added to Tulsa prices to establish f.o.b. and c.i.f. prices almost anywhere else in the world. Since 1949 Venezuelan f.o.b. prices have been equalized with Tulsa prices plus freight from Tulsa to Gulf of Mexico terminals (U.S. Gulf posted prices). For world prices, irrespective of origin of oil, freight from the Venezuelan seaboard to Malta or destinations west of Malta is added to U.S. Gulf coast posted prices. To arrive at prices east of Malta up to the Persian Gulf, freight is deducted from the Malta price. Thus the price f.o.b. Kuwait equals the U.S. Gulf posted price, plus freight from Venezuela to Malta, less freight from Malta to Kuwait via the Suez Canal. Prices at Levant pipeline terminals or European destinations are similarly determined. This price system applies whether the Suez Canal is used or not. East of the Persian Gulf freight is again added until the total price equals U.S. Gulf posted prices plus freight west from Venezuela. There are several exceptions to these rules, but they do not invalidate the basic principles.

Since oil production in the United States is relatively costly this system assures a high price to the profit-sharing, but low-cost Middle East oil producing states. The system prevents large-scale Middle East oil imports into the United States. Suggested revisions would place the price-shed to the west of Malta, reducing Middle East prices particularly for European buyers.

DAVID H. MILLER—*Specifying the Areal Extent of Mountain Snow Cover*

Because snow cover brings about radical changes in the local climate, knowledge of its areal extent is necessary for climatologic research. Unfortunately, in mountain regions of the West that are sparsely settled and diverse in terrain, the finely articulated snow-cover pattern slips through the coarse mesh of surface observations.

The birdseye view given by aerial photography or reconnaissance is often unavailable, and a means is needed to specify extent of snow cover in terms of such elements as snowpack mass or runoff.

Observations by the Corps of Engineers showing snow-cover over drainage basins of two headwater streams and of Kings, Boise, Flathead and Kootenai rivers have been analyzed with respect to other hydrologic elements. It was found that in headwater basins with deep snow, a large fraction of the seasonal runoff occurs while snow-cover is still extensive; a curve of snow-covered area plotted

against accumulated runoff changes little until mid-spring. In large basins, such a curve drops off rapidly in early spring.

In general terms, snow cover in a headwater basin is not reduced to half its initial area until two-thirds of a twenty-inch runoff, or three-fourths of a forty-inch runoff, has passed out of the basin. Snow cover in a large basin, where subsurface storage delays flow, is reduced to half its initial area when half a twenty-inch runoff has occurred.

E. WILLARD MILLER—*Distributional and Functional Changes of Villages in Western Pennsylvania*

The distribution and function of villages in American economic life has received little attention from geographers. The village is, however, most important in the nation's settlement pattern. This paper investigates and analyzes distributional patterns and functional changes of villages from 1820 to the present in six counties—Armstrong, Butler, Clarion, Forest, Jefferson, and Venango—in west central Pennsylvania. All settlements with populations between 25 and 1000 are included. Maximum size of villages investigated was placed at 1000 for it differentiated basically residential settlements and service communities from multifunctional towns where manufacturing plays a significant role. Manufacturing is found in only 15 of the 193 villages and deals essentially with processing local raw materials.

The village pattern began in this region in the 1820's and evolved with expansion of agricultural, mining, and lumbering industries. Consequently, the number of villages increased from 60 in 1850 to 325 in 1920. Village population in 1920 was 63,250, approximately 20 percent of the total six-county population.

Since 1920 the local economy has declined significantly. While many hamlets with less than 100 people have disappeared, villages with populations of 100 to 1000 have remained essentially stable or have increased in size. Although local employment opportunities have declined for rural communities, larger villages have adjusted to the new economic situation. These settlements now serve primarily as residential communities with workers commuting to the region's towns and cities. The future of the villages will depend primarily on ability to attract people who prefer to live in a semirural environment.

PAUL F. MILLER—*Burns Ditch: Proposed Ocean Port for Indiana*

In the Dunes country of northern Indiana a controversy long in development has erupted into an open feud. It has been proposed that a deep-sea port be established at or near Burns Ditch in Porter County. The outcome of this harbor proposal with its attendant industrialization is contingent upon a clash of two opposite land usages. The dunal clusters are ideal for recreation and high-cost residences. Because of several apparent factors, this area is also favorable for industrial development.

This is a study of the economic base of the harbor. It indicates that the strongest justification for port development now is the possibility of large-scale heavy industrialization in close proximity to Burns Ditch. Also it is shown that such commercial development will deteriorate Dunes Park and the high-cost residential areas in the immediate vicinity.

The anticipated traffic emphasizes bulk commodities, mainly coal and grain. Composite estimates from three surveys appear to be optimistic, partly due to an underestimation of the competitive attraction of better-located Calumet Harbor.

Any significant effect the St. Lawrence Seaway might have upon Burns Ditch will be delayed until the location of new industry within the port's trade territory. Without an industrialized *umland*, neither a good variety of bulk goods nor manufactured goods will be handled.

Recently land has been optioned and purchased for large-scale industrialization. This region appears to be on the threshold of commercial development. The present conflict of incompatible land uses will largely determine the direction of this development.

ROBERT B. MONIER AND NORMAN E. GREEN—*Report on Current Research in Aerial Photographic Interpretation as Related to Urban Geographic Studies*

As a part of Air Force interest in aerial photographic interpretation, a research project was initiated to develop methods for identifying specific socio-physical aspects of an urban complex. The over-all design envisaged the use of aerial photography as a source of basic data in terms of indices correlated with residential structures, their types, and spatial distributions. This paper summarizes the work

done to date, and, as such, is a follow-up of a paper presented at the annual meeting of the Association of American Geographers in 1953.

The basic criteria developed in early pilot studies for the identification of residential structures from aerial photographs were refined to permit delineation of residential structure types as a basis for socio-economic areal classification. Combinations of structure types were found to be sensitive indices to differences in social and demographic characteristics of urban subareas. In addition, studies utilizing Guttman's Scale Analysis indicated that material cultural aspects (photo data) were closely correlated with urban social stratification systems. Additional studies investigated the spatial relationships between the human and physical units of several American cities.

While further work is planned to test the developed methods for use in foreign cultures, it is believed that these studies demonstrate the means of utilizing aerial photography in studying the significant relationships between human interactions and the material-cultural physical features of American urban agglomerations.

JACK USHER MOWLL—*The Economic Geography of Nuclear Power*

The critical years for nuclear power will be the decade of the 1960's. Then, much of the technical research and development will be completed; yet the golden age of cheap, ubiquitous nuclear power will not have arrived.

Two channels of growth will be followed: additions to existing central power systems and self-contained installations in regions undeveloped with respect to electrical power. In both cases the initial limiting factor will be the high capital cost of nuclear power plants. The chief advantage will be the convenience of a "weightless" fuel which will burn for 12 months or more without recharging. This indicates that in the 1960's nuclear power will be adopted in regions where it can be most efficiently used, i.e., where the input of power at a given price will permit opening unexploited territory to productive activity, or permit expanded production in marginal areas.

The geographic regions in which this principle will apply are totally inaccessible to bulk transport of conventional fuels, are at the margin of inaccessibility due to unusually high transport costs, or are in strategically vulnerable positions.

The peculiar condition imposed by the high capital cost of nuclear power requires the industry which adopts it to have a high-value export product which will enable quick amortization of the investment and restoration of the foreign exchange used in the transaction.

The industries that best fit these conditions are mining, manufacturing, irrigated farming, and colonization projects. The regions which appear most attractive for such developments are northern Canada, the Caribbean Islands, Latin America, Africa, Western Australia, the Middle East and certain parts of South Asia.

HOWARD J. NELSON—*Walled Cities of the United States*

Though important in the urban geography of Europe and Asia, city walls are given little attention in the study of American cities. Perhaps this is because the topic has been unexplored, for though neither numerous nor permanent, walls have been a significant feature of some American cities.

Many settlements in the United States began with a few cabins surrounded by a stockade. However, perhaps a dozen of our large cities grew to considerable size while boasting bona fide walls. Walls varied from the wooden pickets of Albany to the earth and stone walls of Ogden and the brick walls of Charleston. Occasionally, moats required drawbridges at the fortified gates. In length, the walls ranged from the short segment across the Neck at Boston to the six-mile long wall of Salt Lake City. Heights varied from about twelve to twenty-five feet.

Walled cities were widely scattered around the United States and occurred over a time span of several hundred years. New York's first wall was built in 1644; the bastions of Salt Lake City were standing in 1862. Most walls were left to decay after a short period of existence, but in several cities they lasted four or five decades, and those of Detroit and Albany remained for about a century.

The significance of early and transitory city walls is difficult to assess without individual field studies. However, street patterns, age of built-up areas, and the location of occasional parcels of public land seem related to the existence of these half-forgotten fortifications.

WILLIAM D. PATTISON—*The Original Plan Behind the Rectangular Subdivision of Land in the Old Northwest*

Existing studies are in agreement that we owe the square townships and sections of the Old Northwest to the Land Ordinance of 1785, which embodied in modified form an earlier plan for rectangular surveying. The purpose of the present paper is to indicate the broad significance of this earlier plan which, though often cited, is little understood.

Three general observations are essential to an appreciation of the plan: (1) A novel scheme of measurement was proposed, with the intention of reforming linear and areal measurement in the United States generally. (2) Squares, into which the land was to be subdivided, were designed to control rather than eliminate the southern system of indiscriminate locations. (3) The plan was closely integrated with Jefferson's contemporary proposal for western state boundaries.

The men who drew upon this plan, in composing the Land Ordinance of 1785, abandoned any intention of reforming land measurement and converted the original grid from a means of exerting control over the southern-style system of land surveying to a framework for the accommodation of New England townships. Later, under the terms of the Northwest Ordinance of 1787, Jefferson's proposed state boundaries were set aside. Certain features of the original plan lived on, however, not the least important of which was the idea of rectangular subdivision. Further, in a sense, Jefferson's rejected state boundaries were eventually employed, as will be explained. There is reason to regret that the original scheme for reformed land measurement was not also put into effect.

CLYDE P. PATTON—*An Improved Combination of the Sinusoidal and Mollweide Grids*

Several attempts have been made to combine the best features of the Mollweide and Sinusoidal projections, two equivalent grids with straight parallels, into one world map. J. Paul Goode simply affixed the polar parts of the Mollweide to an equatorial Sinusoidal middle. Boggs calculated a "mean" between the two projections in order to smooth the kinked meridians of Goode's projection.

If we assume that the Mollweide is a better projection for polar, and the Sinusoidal for equatorial latitudes, the best combination is one wherein the new grid partakes completely of the Mollweide at the Poles and gradually acquires more of the Sinusoidal characteristics equatorward. One such projection utilizes the fact that the sum of the squares of the sine and cosine of an angle is equal to unity. Multiplying the y co-ordinates of the Mollweide by sin^2, and the y co-ordinates of the Sinusoidal by cos^2 of the latitude, and adding the products, yields y co-ordinates that satisfy the conditions mentioned above. To maintain equivalence, a different calculation must be made to derive the x co-ordinates, which do not, however, differ much from x co-ordinates obtained in the same way as the y co-ordinates.

The resulting grid is equivalent; its angular distortion is less than that of the Mollweide in equatorial latitudes and less than that of the Sinusoidal in polar latitudes. Hemispheres of the Sinusoidal, Mollweide, and of the new projection, drawn to the same scale, illustrate the relationship between the three.

DONALD J. PATTON—*Spatial Patterns of Some American Atlantic and Gulf Port Hinterlands*

This study discusses some of the spatial aspects of certain Atlantic and Gulf port hinterlands. Analysis is centered on the rail component of general cargo traffic, and on the movement of grain and ore. Total carload origins for a 30-day sample period have been mapped for export traffic through Baltimore, Philadelphia, New York, Boston, New Orleans, and Galveston, and the same has been done for carload destinations on import traffic through the same ports. These maps give a picture of the extent and orientation of the several hinterlands and the varying degrees of hinterland overlap; more significantly, they raise a series of questions relative to the causality of the observed patterns.

Atlantic and Gulf port hinterlands overlap in numerous areas. Most important, however, is an area extending from western Pennsylvania westward through the eastern Middle West to the upper Mississippi Valley, where localities importing or exporting general cargo, exporting grain, and importing iron and ferroalloy ores are closely spaced and responsible for a large aggregate traffic. Eastward, south-

eastward, and southward from this zone the several ports become more dominant in their respective spheres, yet some ports fail to establish relative dominance even in their immediate hinterland. In the case of New York, three spheres of relative dominance are recognized.

An attempt is made to assess the more important causal factors underlying the general pattern of port hinterlands. These include port differential territories, port facilities and services, and the maritime connections afforded at the different ports.

RAFAEL PICO—*Value of the Rural Land Classification Program of Puerto Rico for Purposes of Economic Development*

The Rural Land Classification Program of Puerto Rico, carried out throughout the period of 1949–51, is a detailed inventory of the land uses and of the physical characteristics of the land throughout the Island. This project, originally sponsored by the Puerto Rico Planning Board and the Social Sciences Research Center of the University of Puerto Rico, was later placed entirely under the administration of the Puerto Rico Department of Agriculture. The Director of this survey was the present AAG President, Dr. Clarence F. Jones.

This survey has been most valuable in the implementation of long-range programs for direct economic development. Briefly, the Department of Agriculture and Commerce has used it in setting up long-range programs to increase the Island's agricultural production and also to answer specific requests about the availability of land for certain crops and other agricultural enterprises. The Puerto Rico Planning Board is using the survey data in the preparation of master plans, most specially in a far-reaching agricultural development plan that sets up a pattern for a more intensive agricultural utilization. It is also being used in several other phases of agricultural planning, such as crop studies, plans for rainfall stimulation practices, and in studies to determine minimum wages in various agricultural enterprises and areas. More recently, the land-use map gave the landmarks for the reconstruction of the tobacco barns destroyed by hurricane "Betsy" that hit Puerto Rico last August.

In addition to these vital economic activities that have used this survey, the map and data have proved valuable for a better location of roads and other government facilities.

In the educational field, the Department of Education has under preparation a geography textbook that uses data gathered by the survey regarding crops and areas where they are produced, as well as maps showing land uses. Finally, as a source of information on the Island's agricultural practices and types of farming, it has aided the State Department in presenting that phase of Puerto Rico to the students of the Technical Cooperation Program.

MERLE PRUNTY, JR.—*Soil Erosion and Plantation Migration: Fallacious Concepts Regarding Dissemination of a Southern Cultural Form*

This discussion treats two ideas regarding 19th century dissemination of the plantation occupance form in the South: (1) that plantations originated in the eastern South and "migrated" westward; (2) that plantations *had* to "migrate" because their occupance system exhausted and eroded soils.

Analysis of the first concept indicates that plantations did not "migrate." Apparently few eastern plantations were abandoned. While plantations increased numerically and spread westward, these landholdings—being spatially fixed entities—were not mobile. They spread through creation of additional plantations because a migrating population carried with it a distinctive concept of rural settlement—the plantation occupance form.

The second point is analized via a theoretical model. If an absolutely flat plane, supporting uniform soils and climate throughout, is used to represent the South, it is seen (1) that plantations expanded numerically in the east in crude correspondence to population increments; (2) that westward population movements, and consequent increments in plantation numbers, were necessary to support additional population after most of the eastern South was settled; and (3) that these movements—and corollary dissemination of the plantation occupance form—were bound to occur regardless of soil exhaustion or erosion. Although soil erosion existed on plantations, it did not play a causative or determinative role in their dissemination. When soils are introduced into the model as a variable, it appears that superior soils in interior and western lo-

cales served as magnets which hastened, and directed, plantation dissemination into the interior South.

JOHN R. RANDALL—*The Political Geography of Israel: A Preliminary Report*

The present paper is a preliminary report on, or an outline of, the political geography of Israel, applying the functional approach as set forth by Hartshorne and others.

The internal political relations are examined first: those centripetal in nature as opposed to those that are centrifugal. The creation of Israel resulted from three major factors or conditions: (1) the age-old hope of the Jews for a return to Zion; (2) activity of political Zionism; and (3) the failure or inability of the United Nations and the World Powers to take decisive action when needed. Next considered are those parts of Israel in which the state idea is present.

Centrifugal factors include: an imbalance in economy; a lack of natural resources for industrial development; the arab boycott; the Arab minority; and Jews of oriental culture.

The external relations of Israel are considered next: territorial, economic, political, and strategic. Israel's present boundaries result from armistice agreements only and satisfy neither Israel nor the Arab states that border her; Israel's economy is in large part supported by funds from other states; although a sovereign state, Israel cannot be said to be a free agent in her political relations; Israel has strategic importance from her geographic location and also vis-à-vis the Arab states.

ERWIN RAISZ—*Geostenography*

Geostenography is a system of geographical note-taking that was developed during the excursions after the Congress in Brazil. It was particularly helpful in a shaky autobus, passing rapidly-changing scenery. The method consists of symbols, letters, numbers, and profiles. For example, 200M is a mature land with 200 meter relief. 50V U_7 is a plateau with rivers steeply incised down to 50 meters and with 7/10 upland. Ba_2P_5 is a region with 2/10 in bananas, 5/10 in pasture, and the rest is capoeira (cut-over forest). Land profiles are indicated graphically.

The system is actually a compass traverse from which a land-use map can be made even if no detailed maps are available. It requires an auto compass, a barometer, and access to a kilometer or mile indicator. Nearby features are noted almost continuously as the bus passes them, more distant features at intervals indicating the direction and distance of features. On curving roads notes are taken only while the bus proceeds in the main direction, unless the direction is indicated. Notes are taken sideways either in one or in both directions.

The author applied geostenography to travel in a train, ship, and airplane with equal success, and the results are presented in the article.

ALLAN RODGERS—*The Hinterland of the Port of Genova*

Genova is Italy's leading port rivaling Marseilles as the most important port in the Mediterranean. It has achieved its present status basically because of its location with respect to the rich industrial and agricultural centers of the Po Valley. Through the gateway of Genova, low-value bulk industrial and agricultural raw materials are funneled to the interior and to a lesser degree industrial end-products are exported. Because of its position as a port and break of bulk center Genova was, in the past, in an excellent position for development of those industries which involved the production of semi-processed goods designed for further fabrication in its hinterland.

In this study, available port statistics on commodity flows to and from the interior and rail-truck movement data were supplemented by the use of a valuable corollary source of information. This involved an examination of the extent and character of the contacts of the major industrial plants in the Genova area with the hinterland. Using data secured by plant interviews, maps were constructed showing the sources of raw materials required by these industries and the markets for each of the major products manufactured in the port. Analyses of the relations of the port with its hinterland demonstrated in this paper have furnished a basic key to the growth of port trade and have provided valuable clues as to the development and prospects for expansion of industry in Genova.

ANTHONY SAS—*Dutch Immigration Into Canad Since 1945*

With respect to Dutch emigration to overseas countries during the postwar decade,

Canada is not only the first country with which the Netherlands government made immigration agreements; it is also the nation which has absorbed the largest number of Dutch settlers: about 110,000 out of a total of 245,000 emigrants from the Netherlands.

The large-scale migration became imperative because of the surplus of agricultural and skilled labor resulting from a high birthrate and limited amount of land in the Netherlands. Preference for Canada was the result not only of the demand for labor in primarily rural areas but also of geographic proximity.

For the past ten years the significant aspects of this migration have been: (1) the active assistance to the emigrants and cooperation by the Netherlands government; (2) the agrarian basis of the migration; (3) the predominance of Southern Ontario as the area of settlement; (4) the "en-famille" character of the migration; (5) the desire of the immigrant to become economically independent at the earliest possible moment; (6) the general lack of knowledge of the language predominant in the country of adoption and the slow cultural integration especially in rural areas; (7) the great influence of various religious organizations upon the life of the settlers.

There is no doubt that Dutch immigration into Canada will continue unabated; however, there is every reason to believe that the proportion of agriculturalists will be lower in the future as a result of the increased immigration of nonagricultural workers in recent years.

NICHOLAS J. SCHMIDT, JR.—*Utilization of Geography and Geographers in Corporation Research*

The number of geographers employed by the aircraft industry is increasing steadily. A new "weapons systems" concept initiated by the military for the purchase of major weapons is largely responsible for this trend. Under this concept, designers and producers of weapons systems, such as planes, missiles, or satellites, must consider all facets of a weapon's operation, including the total environmental complex in which it operates.

Geographers in their systematic guises as climatologists, physiographers, meteorologists, oceanographers, logisticians, intelligence and environmental specialists, etc., are called upon to describe conditions, predict values, and recommend solutions to a great variety of environmental and operational problems.

In a company producing weapons systems, geographers have access to a great store of classified geographic and other intelligence data on a "need to know" basis. They also have access to their company's confidential technical library, and, of course, to all of the usual open sources of geographic information. In addition, they are encouraged to consult with experts on any subject relevant to their problems from nucleonics and astrophysics to political science and psychology.

Many geographers employed by aircraft companies today have had military and military intelligence experience. Backgrounds in mathematics, physics, statistics, and basic engineering subjects are definite assets for geographers interested in industrial employment.

BERNARD H. SCHOCKEL—*A Technique in Measurement, Integration, and Areal Differentiation, of Economic Importance*

The intent of the technique here considered is improvement in concomitant measurement, integration, and areal differentiation. The application is to the economic importance of the 3,072 counties of the United States. The core of the formula for each county is

$$\frac{\text{county} \times 100}{\text{Representative County,}}$$

resulting in percentage, which is mathematically flexible in the items used as criteria. The first subproject, now completed, deals with the 92 counties of Indiana, used as a sample.

The area of the mythical Representative County is 675 square miles, which is the average size of the counties of the states east of the Rocky Mountains.

By proportion the values of the Representative County are deduced in the following items, total and per square mile: (1) population, (2) value of products sold from the farm, (3) manufacturing increment, (4) wholesale sales, (5) retail sales, (6) persons employed in mining, and (7) employed persons not included in items 2–6.

With these 14 norms of the Representative County, each Indiana county's percentage of the Representative is calculated for each of the 14 norms. Since the ratings are percentages of the Representative, the 14 percentages of each county are then integrated into one composite,

to produce the county's over-all rating in economic importance. Result: a map of Indiana portraying the economic importance of its 92 counties, each comparable to all 3,072 counties.

FRANK SEAWALL—*An Approach to Hinterland Analysis of River Transportation*

The major purpose of this paper is to demonstrate the practicability of a geographic technique in delimiting and analyzing the hinterland of river transportation for a commodity. The transportation of gasoline on the Monongahela River, one of the world's busiest waterways, has been selected as a case study.

The following procedure was used to differentiate a quantitative hinterland: (1) by field research, delimit the area served by each terminal; (2) measure the area of each of the terminal hinterlands; (3) obtain data indicating the annual amount of gasoline transported to each terminal (unpublished data, but available from United States Engineers, District Office); (4) calculate the mean annual gasoline consumption per square mile in each terminal hinterland; and (5) map the mean gasoline consumption in each hinterland (where the hinterlands are superimposed on one another, the mean consumption of the superimposed areas were totaled). The resulting hinterland map has a gradational pattern, indicating that certain segments of the hinterland have greater access to water transportation than other portions of the hinterland or make greater use of it.

The final phase of this study analyzes the physical, economic, and human factors which are effective in limiting the hinterland to the specific area it occupies, and the causes of the resulting hinterland pattern.

FREDERICK J. SIMOONS—*The Influence of Cultural Attitudes on the Ethiopian Landscape*

Northern Ethiopia was invaded by Semitic farmers from highland South Arabia starting about 1,000 B.C. Their cultural descendants, the Amhara, have pushed across the plateau, extending their political and economic influence southward. The Amhara have brought about striking changes in highland Ethiopian agriculture and in the landscape because of their deep-seated preferences and prejudices. They have preferred the plow to the hoe as an implement of field cultivation; they have disdained the traditional root crops and the banana-like *Ensete* in favor of cereals and pulses as crops, and they have had little interest in the cultivation of tree crops. Moreover, the Amhara measure a man's wealth by the number of domestic animals, particularly cattle, he possesses. The keeping of large herds of animals and the clearing of fields for sowing cereals and pulses led to the creation of a landscape of open fields with herds grazing on fallow or uncultivated land. The agriculture of the northern plateau contrasts strikingly with that of unaltered parts of the southern highland where root crops and the *Ensete* are important, where farmers are often concerned with individual plants which may be grown in gardens or native plantations, and where the hoe replaces the plow as the principal agricultural implement.

The changes in Ethiopia's agriculture illustrate the general need for assessing the role of cultural attitudes in modifying the landscape.

ROBERT SINCLAIR—*Coal Port Hinterlands of Northern Ireland*

Because Northern Ireland is practically devoid of fuel and power resources, coal ports are of outstanding importance in the Province's industrial economy. In spite of Northern Ireland's small size, no fewer than eight ports compete in importing and distributing industrial coal. Hence, an areal pattern is evident in the movement of industrial coal to the Province's industries, a pattern which comprises the distributary hinterlands of the respective ports. This study precisely delimits the coal hinterlands of the various ports and considers the factors which have brought about the hinterland pattern.

The pattern and size of coal port hinterlands in Northern Ireland have been relatively stable, in spite of changes in coal sources, modes of transportation, and degree of competition between importers. The pattern basically expresses the advantages and disadvantages of individual ports and port areas. Briefly, these fall into three main groups: (1) locational factors (both internal and external), (2) port facilities, and (3) efficiency of delivery operations. The relative importance of each of these factors is analyzed as the hinterland of each port is considered and explained.

DAN STANISLAWSKI—*Migration and Environment*

In the archaeology and history of Spain and Portugal there is record of several immigrant farming groups. Each of these, because of the diversity of Iberian conditions, was able to choose land suitable to its needs. In nearly all cases, this resulted in the choice of an area for settlement climatically akin to that from which the group had begun its trek.

Early African migrants spread along the Mediterranean shores through a long period of time. Phoenicians, Greeks and Carthaginians, all Mediterraneans, later skirted the same shores for trade and established trading settlements. Rome took power everywhere in the peninsula, but did not establish agricultural settlements of any importance beyond the limits of Mediterranean climate. Muslims also took power over most of the peninsula, but within two generations had relinquished the unwanted non-Mediterranean lands at the north.

Central Europeans found the north and northwest of Iberia to their taste. Celts and Germanic peoples began to filter into the peninsula by 900 B.C. and continued to do so for at least five centuries. Later Germans (the Suevi of the fifth century A.D.) chose the same general area for concentration and followed the northern fringe and the west coast down to central Portugal. Another Germanic group, the Visigoths, being dominantly herders, chose the central plateau land (as had some Celts) where their cattle could graze.

None of these early migrations has failed to make its impress upon Iberian life. The effect of the Suevi is still to be seen in the northwest. In many respects the quality of life of the Mediterranean region harks back to that of the early immigrants. Even the Visigoths, who left little materially, have left strong remnants of their feudal attitudes, especially in the Castiles.

KIRK H. STONE—*The Norwegian Edges of Settlement: Measures of Permanence*

This is part of a general research program to develop rules to insure the permanence of first settlement in an area. The specific objective is to analyze the permanence of residence in the Norwegian margins of settlement, the areas believed most suitable for the formulation of rules to insure the permanence of new settlement in adjacent unoccupied lands.

The 1950 marginal zones of permanent residence in Norway are mapped as stable and unstable settlement zones. The former are those parts of the edges of settlement which have been stable in position and population numbers since 1920 or earlier. The stability is analyzed by location and by topics indicating possible measures of the permanence of the population.

Unstable marginal settlement zones are mapped as areas of new settlement since 1920 and as areas of continuously decreasing population since 1920. Each of these is analyzed by location and by topic to determine causes and degree of permanent and impermanent residence.

Further studies needed to formulate rules for the process of settling permanently are suggested.

ARTHUR N. STRAHLER—*Objective Field Sampling of Physical Terrain Properties*

Objective, quantitative terrain analysis useful in military and engineering applications measures purely physical properties of the ground surface relevant to problems faced. Relative to facility of dispersed cross-country movement on foot or in vehicles, an element of ground surface may be analyzed in terms of resistive forces set up by ground slope, surface roughness, soil weakness, and vegetation. Inhibition of movement depends upon the sum of these resistive forces weighted on a performance basis. A barrier to movement is then defined as a terrain element in which the sum of resistive forces exceeds the impelling forces.

A summer field sampling program in central Maine provided data on mean values and variances for within-area and between-area analysis of three basically different terrain types with a wide range in geological properties: (a) bouldery thin till on granitic bedrock with hardwood forest, (b) bog on clay with hemlock forest, and (c) sand plain with pine forest. Roughness, or micro-relief, was sampled on random 100-foot transit lines with a level rod, measuring mean and total lift heights to overcome roughness. Resistance of surficial soil to shearing was sampled uniformly along these sight lines by Proctor penetrometer. Trunk diameter and tree frequency were measured in 40-foot

sample circles located by random azimuths and distances. Significant differences exist in means or variances between areas, suggesting the practicality of describing and differentiating terrain classes on statistically-defined terms while at the same time supplying maximum information on physical properties.

EDWARD J. TAAFFE—*Route Elasticity of Demand—Geographic Application of an Economic Concept*

The economist's useful concept of elasticity of demand may be applied to a map study designed to evaluate the impact of low coach fares on the spectacular growth of air traffic during the past five years.

Maps portraying traffic growth are first compared with maps of coach fare percentages and average per-mile fares over Chicago's principal air passenger routes. Regression analysis and total revenue changes for each route are then employed to determine the average relationship between coach fares and air traffic growth. Those routes which show greater traffic growth than would be expected from the percentage of coach traffic may be regarded as having a relatively elastic demand for air travel. A map is then prepared to show the distribution of the relatively high and relatively low elasticities. Analysis of this map indicates that:

1. Product competition in the form of improved services has been a more important factor in generating air traffic growth over individual routes than has price competition in the form of reduced fares.
2. Recreational traffic is extremely elastic. A decrease in fares on a winter resort results in a disproportionately great increase in traffic.
3. There is a distance-linked differential in elasticity of demand. The longer the route, the more responsive it is to fare reductions. This has led to the development of a selectively applied tapering fare structure with the longest routes having the greatest percentages of coach fares and resultantly lower per-mile fares.

WILLIAM L. THOMAS, JR.—*The Geographer as a Student of Man's Role in Changing the Face of the Earth*

At the AAG annual meeting twenty years ago, there emerged from a round-table discussion on the "Cultural Geography of North America" some larger ideas and questions with regard to cultural geography itself. A healthy variance of views was reported on four points:

1. What is meant by "cultural geography," and how is its study to be pursued?
2. How are "culturogeographic areas" to be marked out and classified?
3. Should cultural studies be concerned with observable, material facts only, or should the intangibles be considered?
4. Can detailed field studies be so directed and their results so presented that they will fit into a larger framework of synthesis and serve as a basis for valid comparisons and sound generalizations?

This paper reconsiders these questions, twenty years after. In light of the current status of cultural geography as reflected in the other contributions to this present session devoted to the subject, one may ask whether, over time, we have not been rephrasing the questions. Are we still searching for the meaning of cultural geography? Do we now know how to pursue its study? Is the delineation of "culturogeographic areas" as important as it once seemed? Are we still as shy about treating intangibles? Have we found a larger framework of synthesis into which our studies can fit?

The theme of man as an agent of change on the earth is examined in relation to culture, considered as both a product and an agent of human evolution, and in relation to its contribution as a "framework of synthesis" for "culturogeographic" studies.

JOHN H. THOMPSON—*Manufacturing in the Kita Kyushu District, Japan*

The cities of Yawata, Wakamatsu, Tobata, Kokura, and Moji in northern Kyushu, and Shimonoseki across the Strait in Honshu together comprise one of Japan's major industrial districts. The purpose of this paper is to describe and interpret the spatial arrangement of manufacturing within this industrial concentration.

Factories with ten or more employees, some 850 in all, were mapped, and their locations studied. The Yawata Iron and Steel Company, the largest integrated steel plant in the Orient, is outstanding both in its number of employees

and in its power to attract satellite industries. Other large-scale factories turn out such products as chemicals, glass, cement, electrical machinery, and ships. Eighteen of the twenty Major Groups of the Standard Industrial Classification are represented.

Factory sites are of two types. The first is found along the Strait of Shimonoseki and around Dokai Bay. Here, largely on filled land, are located the large-scale, heavy industries which can profit from direct access to limestone, coal, sand, and other materials via ocean shipment. These sites are also served by railroad sidings and good roads. The second type of site is situated back from the shore where the factories exhibit a scattered pattern through the built-up area of the cities. Medium- and small-scale concerns predominate. Many are satellite to the large-scale factories on the shore sites or are ubiquitous in character. Small trucks and bicycles are the prime means of transport to and from these sites.

KENNETH THOMPSON—*The Origin and Utilization of the English Peat Fens*

The Fens of eastern England comprise a distinct region, formerly marsh but now reclaimed, covering some 1,250 square miles. The region has for its main characteristics poor natural drainage, extreme flatness, and low elevations. These peculiar physical characteristics result from an accumulation of material, mainly peat and silt, within a shallow basin at heights around present sea level. Nowadays the Fens form the largest continuous tract of first-class arable land in the British Isles.

This paper is concerned primarily with the highly fertile peat deposits which make up nearly one-half the Fen area. Such peat developed in former freshwater marshes in the interior sections of the Fens where waterlogged conditions inhibited decomposition of plant remains. The circumstances under which Fen peat originated are examined in the paper, particularly inasmuch as they have bearing on the present agricultural value of the soils under reclamation.

Unusual land utilization problems occur in the peat Fens and the major of these are considered. These problems include the need to keep the region free from flooding by means of a complex system of artificial drainage and difficulties raised by the constant shrinkage of peat levels. Other aspects of the peat Fen environment that condition human activities are examined. The paper goes on to analyze the utilization of the peat Fens. Nowadays this is almost entirely through agriculture of the intensive type. On the basis of selected representative sample areas (surveyed by the writer in 1953) generalizations are made regarding the crops and livestock of the region. It is pointed out that some wastage of the organic Fen soils is inevitable if the peat is to be farmed. However, the present high wastage rate may be reduced by following certain conservative practices, which are outlined.

NORMAN J. W. THROWER—*Cadastral Survey and Roads in Ohio*

That the qualities of a basic system of cadastral survey should strongly affect the lineaments of resulting occupance and use of the land is all but self evident. Yet few attempts have been made to describe these effects carefully and measure them with any precision. This paper reports on an effort to make a quantitative comparison of a major group of these lineaments, i.e., road patterns, as developed under two contrasting cadastral survey systems.

There are many places in the United States where side-by-side comparisons of different cadastral systems can be made, but the state of Ohio is particularly useful. Here on a part of the till plain remarkably homogeneous in all characteristics examined, the two major survey systems of the United States, the rectangular and the indiscriminate (metes and bounds) abut. For this study sample areas from the indiscriminately surveyed Virginia Military District of Ohio were compared with samples of equal size from the area of rectangular survey to the northwest. The features examined include the total mileage of roads and the coincidence of roads with the boundaries of minor civil divisions as well as the arrangement of properties with respect to roads.

It is concluded that the character of our contemporary land use owes a good deal to the choice of an original system of cadastral survey. The investigation does not demonstrate the superiority of one type of survey over another, but reveals differences in detail which

may have significance in their results as seen in the development of patterns over a century and a half.

GLENN TREWARTHA—*Weather as Related to Jet Streams in the Orient*

During the warmer months the westerlies and their jet stream in eastern Asia are confined to the northern side of Tibet. In the cooler seasons this high terrain obstacle bifurcates the jet so that one branch flows south of the Himalayas and the other to the north of Tibet. Their confluence is in the vicinity of Japan.

Some significant weather effects of the jets are:

1. The so-called winter monsoon of South Asia and its associated drought are the consequence of strong subsidence south of the Himalayan jet stream.
2. The appearance of the jet south of the Himalayas marks the beginning of the winter climatic regime of South Asia. The narrow band of winter rainfall in Northern India is derived from disturbances which develop under the jet and follow it across the subcontinent.
3. The beginning of the summer weather regime in India, the burst of the monsoon, is synchronized with the sudden disappearance of the jet to the north of Tibet. This also marks the beginning of the *bai-u* rains in Japan.
4. The path of the Himalayan jet across South China is marked by a concentration of disturbances and of winter rainfall under the jet. A rainy-day maximum and a minimum rainfall variability likewise coincide with the jet's position.
5. Abnormally steep winter temperature gradients in China are related to the converging jets with contrasting trajectories to the lee of Tibet.
6. The two regions of winter cyclogenesis over the waters near Japan coincide with the positions of the two jets.

DUANE C. TWAY—*The Evolution of Geography in the AFROTC*

Since the inception of the AFROTC generalized curriculum approximately a quarter of a million college students who might not otherwise have done so have studied some geography.

When Headquarters USAF directed the Air University to prepare a generalized curriculum for AFROTC, one of the specific objectives stated that each graduate of the AFROTC program should "be acquainted with areas of knowledge which are especially pertinent to officers on duty in the USAF" among which was listed world political geography and its relation to air power.

The planning group which developed the generalized curriculum drew up three objectives which clearly indicated a need to teach a course in global geography, which course we now teach in the freshman year. Under the specific objective already cited, this planning group also determined that world political geography and its relation to air power should be given considerable emphasis. As a consequence, a course titled *Military Aspects of World Political Geography* is offered to senior cadets.

Textbook development proceeded from this initial planning with assistance of a committee selected by the president of the Association of American Geographers. Geographers have been closely connected throughout the existence of our program with both textbook preparation and instruction.

Among interesting projects presently under way for improving geography courses is one at Ohio State University involving use of professional geographers. From this project has grown a plan for initiating summer school courses for AFROTC instructors in geography and other courses.

JACK RICHARD VILLMOW—*The Climates of Europe According to the Thornthwaite Classification of Climate (1948)*

Unpublished data obtained in cooperation with the Blue Hill Meteorological Observatory, Milton, Massachusetts, is utilized in the preparation of a series of new climatic maps of Europe. Application of the Thornthwaite classification of climate (1948) allows a new insight into (1) the arrangement of moisture regions, (2) the distribution of the summer concentration of thermal efficiency, (3) the distribution of effective moisture, and (4) the distribution of average annual thermal efficiency. Comparisons of these climatic maps with the standard Koeppen maps are made.

STEPHEN S. VISHER—*Aspects of Conservation in Indiana*

Indiana, a representative state, affords an appropriate area for which conservation progress can be summarized.

Indiana's resources have been increasingly effectively used in numerous ways. Clearing was generally necessary before agriculture was practicable, but land with considerable slope should have been left wooded because soil erosion is rapid on cultivated slopes. About a third of Indiana formerly was too wet for successful agriculture. Drainage has greatly increased productivity. Recently, pulverized limestone has widely counteracted excessive soil acidity, and much mineral fertilizer has been added. Cultivation has greatly improved, crop rotation is practiced, and better adjustment of crops to soil has been made. Hybrid corn, soybeans and tomatoes have conspicuously increased crop returns.

Mineral resources have been progressively used more adequately. Strip mining has wasted relatively little coal, but most stripped areas are left in a "ruined," condition. Few of the spoil banks are wooded. The use of sand, gravel, and clay has greatly expanded and the crushed and building limestone industries have become notably important. Moreover, a new mineral resource, gypsum, has recently been found.

Indiana largely wasted most of its formerly great forest resource and little of the present woodland is managed wisely.

Many forms of wildlife have become extinct. Much ineffectual effort has been spent to recoup the formerly rich resource of fish.

With respect to outdoor recreational areas, Indiana has made much progress and now has numerous state parks and city parks, but facilities have not been expanded as much as the demand for them.

Thus the wiser use of resources—conservation—has progressed significantly, although much remains to be done.

WALTER H. VOSKUIL—*United States Mineral Resources for the Future*

An intensive and comprehensively planned program of mineral exploration and discovery is the most important single factor in maintaining an adequate supply of available minerals.

This program requires the services of a large staff of geologists and geophysicists adequately equipped with the essential instruments of exploration.

Exploration, even though it results in substantial discoveries, will not be adequate without the aid of the miners, metallurgists, engineers, architects, and contributions from deposits in foreign countries.

Developments in mining—such as diamond drilling, block caving, and removal of overburden—have contributed toward making ore deposits of low grade economically exploitable, thereby increasing the supply of metal that can be made available.

Metallurgy is assuming an increasingly important role in bringing low-grade ores or ores of high impurity into the realm of economic ores. Examples of such contributions by process metallurgy are the combined process of treating siliceous bauxite for the production of alumina, sintering iron ore fines preparatory to smelting, and separating and recovering rarer metals from complex ores.

Mineral resources in foreign countries vary in their availability and accessibility to the United States. Growth of industrial production abroad will increase competition for mineral materials among older and newly developed industrial nations; also nations will tend to reserve for their own use minerals hitherto exported. Availability of foreign minerals may be further limited or curtailed by adverse foreign exchange policies or by hostile intent. International agreements mutually advantageous should be encouraged, particularly with nations geographically accessible.

PAUL P. VOURAS—*The Logical Status of the Island of Rhodes—A Case Study in Political Geography*

The purpose of this study was to determine from a geographic viewpoint what Rhodes' logical status should be: (1) continued affiliation with Greece; (2) a return to Italian or Turkish rule: (3) conversion to an independent state. Under the treaty of Lausanne, Rhodes was transferred from Turkey to Italy. In 1947, sovereignty of the island was again shifted, this time to Greece. In both transfers the decisions of the statesmen were based on non-geographic factors.

The economic development of Rhodes was directly or indirectly subsidized by each of the

governing nations. Unlike Italy and Greece, Turkey did not actively engage in the economic development of the Island. The former, however, undertook measures to develop the island's economy. Despite the limited progress made, the island still had to depend on Turkey to meet its food requirements.

In the light of the circumstances permanent status of Rhodes presents an almost insoluble problem. An independent national existence could be maintained by Rhodes only by lowering its present standard of living. Italy is no longer interested in possessing Rhodes because the recent political developments in the Middle East have made the area less attractive as a colonial area for European powers. Neither Turkey nor Greece has the capacity to assist Rhodes in advancing its economic development. On the basis of social-cultural elements alone, the attachment of Rhodes to Greece would be logical. From the economic viewpoint, however, Rhodes apparently would fare best as a part of the Turkish mainland.

If there is a solution to the problem, it would have to come from the Rhodians themselves.

GILBERT F. WHITE—*U.S. Water Resources for the Future*

Projections of water supply and demand for the nation as a whole have value chiefly in setting the broad limits within which use of water resources may be expected to develop. The grounds for the Paley Commission and Commerce projections for 1950-75 are reviewed, and their possible application to a longer period is appraised.

More likely to be useful in forecasting shortage are regional projections which recognize areal differentiation of withdrawal and nonwithdrawal uses and of consumptive and nonconsumptive uses in relation to mean and minimum water surplus. Some measures of those relationships are proposed.

Major factors affecting possible shifts in regional supply and demand are examined, and attention is given to the social limits to irrigation in arid zones, the physical limits to irrigation in humid zones, the effects of improved land management upon water supply, the improvement of efficiency in nonconsumptive uses as related to demand elasticity and technical innovation, and the prospects for change in physical supply.

ALFRED J. WRIGHT AND HENRY L. HUNKER—*The Northwest Territory, 170 Years After*

The identity of the Old Northwest Territory persists as the East-North-Central census division. It became the nation's first corn and wheat belt a century and a half ago as a result of the fame of its soil and terrain, its free or cheap lands, and its relative accessibility to the older seaboard states. No comparable area of the nation was settled as rapidly, then or since.

It remains an important agricultural area today but the economy is dominated by manufacturing. Its accessibility has increased as the Ohio River, Great Lakes, and overland routes have become vastly more important. The five states—Ohio, Michigan, Indiana, Illinois, and Wisconsin—lead the nation with almost 32 percent of all manufacturing by net value.

After a depression, the Second World War, and a postwar period of unparalleled industrial activity, these states remain leaders as a census division. Only Ohio, smallest in area of the five and 35th among all states, displays industrial vitality so far above the national average as to raise its rank from fourth to second within the past seven years. Indiana and Michigan are the other Territory states which have managed to keep pace with the nation's industrial growth.

The fact that Ohio exhibits a dynamic growth not common to the other four states suggests the need for a re-appraisal of industrial activity there. In addition to a survey of the changes in manufacturing activity and industrial localization in Ohio during the past 15 years, we have evaluated the orthodox location factors as well as the less obvious but often more important factors of linkage, industrial structure, recentralization, market characteristics, and the role of government as they have influenced industrial growth.

WALTER F. WOOD AND JOAN B. SNELL—*The Dispersion of Geomorphic Data Around Measures of Central Tendency*

A voluminous amount of data was gathered from a random sample of over 200 USGS and AMS topographic maps of the United States. As a first step in the analysis of this information, means of several terrain factors were computed.

The mean relief of a 5/16 square mile area is 240 feet and for a 160 square mile area it is 1,420 feet. A successive doubling of areas

from the smallest of the limits to the largest produces means of relief which fall into a regular progression. This permits the construction of a nomograph for determining the mean relief of areas of any size lying between 5/16 and 160 square miles.

Other information of interest computed from these data includes an estimate of about 2,300 feet for the average elevation of the United States. A 20-foot contour is crossed on the average of every 290 feet of random traverse. On a similar traverse, 3 ridges averaging 150 feet above valleys would be encountered about every mile. Hilltops rising sufficiently above other land to be represented by a closed contour occur on the average of one every quarter square mile.

The above mean values probably seem extreme, but modes and medians have values of a smaller magnitude. The strong skewness of geomorphic data indicated by the spacing between the means and medians calls for a kind of analysis different from that used with normal distributions.

JORGE ZARUR—*The São Francisco Basin Project, Brazil*

The purpose of this study was to survey and analyze the basic resources and livelihood activities of the Middle São Francisco Basin, and to indicate the direction of desirable development potentialities in the agriculture, power, forest, and other natural as well as human resources of the region.

The São Francisco, being 3,161 kilometers long, is the largest river system of the Brazilian Plateau. It is a multiple-purpose river with large hydroelectric power potentialities and an important cheap transportation system and water reservoir for a region where a regular and sufficient water supply is not available. Large portions of the area are semiarid. Grazing and farming are basic productive activities. Trade and transportation are important activities. Vegetable gathering and manufacturing of the artisan type are secondary phases of the regional economy. Education is chiefly primary. Health and sanitation constitute serious problems. Credit and banking facilities are inadequate. The taxation system limits the development of the region. Public works carried on are few and uncoordinated.

It was recommended that a São Francisco Valley Authority be formulated to coordinate plans for integrating various problems of land, water, and people. As a result the São Francisco Hydroelectric Company was established in 1945 to make available industrial hydroelectric power. The first plants, inaugurated in January 1955, are valued at some 29 million dollars.

The São Francisco Valley Authority was created in 1948 with a nine-point program of development to be accomplished within a period of twenty years. The points are: (1) general studies and surveys, (2) river control, (3) power, (4) transportation, (5) irrigation and drainage, (6) health, (7) cultural development, (8) production development, and (9) industrial development.

WILBUR ZELINSKY—*A New Approach to the Study of Changes in the Distribution of Manufacturing in the United States, 1939-47*

After grouping all counties into 459 State Economic Areas, classified as metropolitan or non-metropolitan and industrial or sub-industrial, a system of six industrial and nine sub-industrial regions is derived. Distributional shifts among the regions and SEA's are measured by applying five indices, each of which gauges change in fraction of national total reported for unit area for: (1) value added by manufacture (V factor); (2) value added by manufacture, allowing for change in total population (V:P factor); (3) production workers (E factor); (4) production workers, allowing for change in total population (E:P factor); (5) value added, allowing for change in number of production workers (V:E factor).

The general tendencies recorded in earlier studies appear—"decentralization" to non-metropolitan and sub-industrial areas—but striking differences emerge among spatial patterns for various indices, and individual SEA'S rarely behave consistently in terms of all indices. The sharpest regional differences appear for E and E:P and for V:E factors: strong gains for Midwest and substantial losses for New England, Middle Atlantic, and Southeastern industrial regions as measured by the former, and the inverse pattern as measured by the latter. In terms of V and V:P factors, greatest gains are recorded for the Southern regions and western Midwest. Adding the population factor to formulae radically trans-

forms status of many regions, reducing Pacific states and Florida to strongly negative status, cancelling most of apparent increases in Texas and Gulf Coast industrial centers, and converting the New York City area from negative to strongly positive.

LEONARD ZOBLER—*Comparisons of Regional Differences by the Use of Variance Analysis*

The F test of significance, through the methods of the analysis of variance, is used to build regions by ascertaining whether there is an association between an areal construct and the distribution of selected characteristics. Variance analysis is a measure of association based on a ratio of between regional and within regional variations.

The problem was to decide with which one of three state groups to place West Virginia—Mid-Atlantic (N.J., N.Y., Pa.), South Atlantic (Md., Del., Va., N.C., S.C., Ga., Fla.), or East South Central (Ky., Tenn., Ala., Miss.). The data employed were the ratios between the number of workers in manufacturing and in the primary industries. F tests were run on the three regional constructs resulting from the shifting of West Virginia among the state groups.

The results showed significant regional differentials at the .001 level of probability when West Virginia was placed in the East South Central and South Atlantic state groups; significant differentials were shown for the Mid-Atlantic states at the .05 level. Because the same number of degrees of freedom was involved in all the tests the F values may be used to rate the regional constructs with respect to their degree of association with the areal distribution of the labor force.

The tests may be interpreted to mean that the highest degree of regional differentials in the labor force is obtained when West Virginia is included with the East South Central States.

REVIEW ARTICLES

A REVIEW OF REGIONAL GEOGRAPHY

Regional geography is the heart of geography—so they say. Statements to this effect, made during the past 40 years, have been repeated and apparently accepted by many American geographers. To establish the validity of the idea the bare statement from previous authority has been repeated, but beyond that little progress seems to have been made in proving that regional geography really is the heart of the subject.

The chapter on the regional concept and the regional method by Whittlesey's committee in *American Geography: Inventory and Prospect*[1] is a contribution on various theoretical aspects of regions. Following this, a flock of recent books on American regions has given evidence that regional geography in some form or other is still alive and engaging the attention of authors and readers. These books provide the occasion for another critical look at the subject.

Probably regional geography has been hindered by an old pair of definitions contrasting systematic and regional geography. According to this couplet, systematic geography deals with *something* about *every* part of the world, and regional geography deals with *everything* about *some* part of the world. Under this limitation, regional geography could not be systematic, and systematic geography could not be regional.

Luckily for geography, both regional and systematic geography have gone on their way without strict observance of the definition, although there have been qualms of conscience, particularly in regional geography, for covering less than everything in an area.

Actually most regional geography has been systematic for a long time—not attempting to include everything about an area but selecting analytically certain phenomena for discussion.

An old form of geographic data, the compendium of information about areas, compiled for reference, continues to be popular and useful and to attempt to include everything about areas that anyone might want to know. But this is only the raw material of regional geography, not the finished product.

A more intellectual literary product is the compages, explicitly designed as the most comprehensive form of regional geography to include everything about human occupance in an area, defined by Whittlesey in *American Geography: Inventory and Prospect*,[2] and exemplified by him in his address on "Southern Rhodesia—An African Compage."[3]

The compages is the least systematic and the most highly recommended regional form in Whittlesey's chapter, though other forms and modes of approach are included there also—or at least hinted at—and are worthy of further consideration in an attempt to scan the present state of regional geography and to see where it is going. The recent regional books indicate some of the lines of travel and stations along the way.

Look first at the simplest and clearest case, *The Agricultural Regions of the United States*, by Ladd Haystead and Gilbert C. Fite.[4] The title indicates the basis on which criteria have been selected. The purpose has been to identify and characterize uniform regions based on a single feature or a group of features distinguishing types of agriculture.

The authors are not geographers, but they know how to write and know about agriculture both as practitioners and as theorists, and they are familiar with common-sense tools of agricultural geography and economics. Interesting anecdotes from personal experience are interspersed with generalized statistical data on acreages, tonnages, and percentages.

The regional divisions are not products of rigorous research and are not rigorously treated. They are groups of states approximating areas of agricultural uniformity in an elementary way and serving well enough as a basis for generalizations in easy, popular reading.

That the authors are not over-impressed by the importance of their boundaries is indicated by the fact that in several cases border states are included in both of the adjacent regions and are discussed first as belonging in one region and then as belonging in another, emphasizing the different aspects relevant to each region.

As a matter of fact, in one case, "The Southwest," all the component states are assigned to other regions also: Texas and Oklahoma to "The Western Prairies and High Plains," Texas also to "The Deep South," and New Mexico to "The Rocky Mountain States." There seems to be no basic objection to such overlap so long as the easy-going perspective of the discussion is preserved.

Only rarely is there a loss of this perspective when some feature of a border state is discussed as a variant within a region merely because the state boundary includes it, instead of leaving it for discussion with the adjacent region. For example, the chapter on "The North North-Central Region: Dairyland" includes the corn-hog economy of southwestern Minnesota and the wheat and flax of northwestern Minnesota as well as the body of dairyland relevant to the regional discussion.

On the whole the book seems to fulfill its expressed purpose of being not a product or tool of geographic research but "a concise guide" for would-be farmers: "where to farm or ranch, what to grow, how to apply the newest methods and equipment."

The other books all deal with parts of the United States, not with the whole. All go further toward

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[1] D. Whittlesey, "The Regional Concept and the Regional Method," in P. E. James and C. F. Jones, editors, *American Geography: Inventory and Prospect* (Syracuse: Syracuse University Press, 1954), pp. 19–68.

[2] *Ibid.*

[3] *Annals*, Association of American Geographers, Vol. XLVI (1956), pp. 1–97.

[4] Ladd Haystead and G. C. Fite, *The Agricultural Regions of the United States* (Norman, Oklahoma: University of Oklahoma Press, 1955). xx and 288 pp. Maps, illustrations, bibliography, index. 6 x 9. $4.00.

comprehensive coverage instead of confining attention to only a few selected criteria. Three of them are the work of many geographers put together by one or two editors.

One of these, edited by John H. Garland, covers the North American Midwest in 16 chapters written by 15 contributors.[5] This book has a coherence that is remarkable in a volume thus compiled and shows indications of a consistent viewpoint held by the editor and impressed on the book through hard work and determination.

The viewpoint is indeed to be classed as belonging to modern "regional geography." The book is composed in full view of the best recommended regional theory in *American Geography: Inventory and Prospect*. The editor says in his preface:

> "The Midwest is considered a total region or compages within a hierarchy of regions of ascending and descending magnitude. . . . The Midwest is definitely a nodal region with a clearly defined structure. It consists of an inner zone of several diverse regions, in one of which is imbedded the second largest metropolitan core in the country, surrounded by a periphery of several diverse regions in which lies the indistinctly defined regional boundary. . . . Little attention is paid to regionality or sectionalism. . . . The term [regional?] is utilized strictly in a geographic sense to indicate the associations and interrelations of human, cultural, and natural environmental conditions within an integrated earth area. . . . the total region, a compages, consists first of all of an earth area, including the fourth dimension [time?], within which lives a population whose impact upon the natural environment produces the culture. The presentation and interpretation of these interrelated elements of the region and the interregional connections, qualities of site and situation, are the geographic factors."

Though called by the editor "a nodal region" the Midwest is treated prevailingly and consistently in the text under the concept of regional uniformity based on selected criteria. This underlies broad generalizations for the whole region and more detailed generalizations for ten constituent subregions, each representing certain aspects of local diversity within the big region.

The Midwest is taken to include approximately the areas called in Haystead and Fite's book: "The Corn-Soy Belt," "The North North-Central Region: Dairyland," and adjacent parts of "The Middle South" and "The Western Prairies and High Plains."

The region and its subregions are clearly shown on maps with suitable boundaries independent of irrelevant state lines. This does not mean that the states are ignored; they are included in discussion when they seem relevant as organized units or useful as statistical units. Four of the subregions are described convincingly as "the heart of the region" and the other six as "the Midwestern periphery," thus satisfactorily providing a zone of transition in place of a sharp boundary between the Midwest and adjacent regions.

The over-all result shows the advantage of having 15 contributors who are not only familiar with the areas of which they speak by having lived and studied there, but who also are familiar with modern regional geography and the viewpoint of the editor. The book is more coherent, informative, and interesting than a reader who has lived his life in the Midwest might expect.

California and the Southwest, edited by Clifford M. Zierer,[6] with 34 chapters written by 32 contributors, belongs in the same regional series as *The North American Midwest* and has been issued by the same publishers. It is similar in appearance and has similarly been edited and written by American geographers and is described as a "regional geography."

Beyond this superficial similarity it is interesting to discover that this is a different book with a different personality. In the first place there is a greater variety of contributors, a majority of them apparently not geographers, and in the second place the editor has had a different viewpoint and a different policy. Instead of working to bring the separate contributions into consistent form within an over-all plan covering the book, the editor has allowed each contributor to tell his own story in his own way. There are some advantages in this policy: writers are free to do their best, and the book contains a great variety of contributions along different lines.

Variety of viewpoint and mode of presentation is accentuated by the fact that each chapter deals with a different topic as it appears in the whole region covered by the book. Or at least 30 of the 34 chapters deal with separate topics for the whole region, and the other four chapters are: an introduction to the whole region, two chapters about landforms in two parts of the region, and one chapter entitled "Radio and Television in Los Angeles."

Most of the chapters are on familiar standard topics in a familiar order. First come "Physical Characteristics of the Region" in 8 chapters, taking up the elements of the natural environment in conventional sequence. Then "Cultural Characteristics of the Region" in 25 chapters grouped under 6 headings: (A) Indian occupance and early white settlement, (B) agricultural activities, (C) other kinds of resource use, (D) manufacturing industries, (E) transportation and trade, and (F) population patterns and political relationships.

Since each chapter covers the whole area and each author has used whatever areal subdivisions he sees fit to present his topic, there are various sorts of subregions in different chapters. This reduces the chance of coordinating and synthesizing the facts and ideas from chapter to chapter. But in view of the sharp distinction between chapters on the basic of topics, coordination is a minor consideration in any case.

The areal subdivisions most commonly used are the 4 states covered by the book: California, Nevada, Utah, and Arizona. As subregions these states are more suitable for some topics and less suitable for others, but in all cases they are convenient statistical units, and, to the extent that they are used, they serve to allow some comparability between chapters.

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[5] John H. Garland, editor, *The North American Midwest: A Regional Geography* (New York: John Wiley and Sons, 1955). x and 252 pp. Maps, illustrations, bibliography, index. 7¼ x 10. $8.00.

[6] Clifford M. Zierer, editor, *California and the Southwest* (New York: John Wiley and Sons, 1956). x and 376 pp. Maps, illustrations, references, index. 7¼ x 10. $11.25.

As for the regional unity of the whole area of the 4 states together, this is fairly clear for some topics and not so for others. In some respects the boundaries of the area seem to correspond approximately with valid limits of a region of common interests. In other respects the boundaries seem purely arbitrary in separating the area from other parts of the United States or from the country as a whole.

Obviously the prevailing regional idea in the book is that of uniformity or homogeneity within the area and difference from adjacent areas, even though some of the topics do not lend themselves to such treatment or at least are not so treated.

The main contribution of the book is not as a demonstration of regionality of any sort, but as a source of authoritative information on many topics in one area of the United States by specialists who are also inhabitants of the area, 28 of them living in California.

The Pacific Northwest, edited by Otis W. Freeman and Howard H. Martin,[7] with 27 chapters written by 30 contributors, is a third volume in the same regional series, issued by the same publishers and edited and written by another team of American geographers. This was in fact the first of the series, published in 1942 and appearing now in its second edition. It has been brought up to date, but the form and spirit are unchanged.

It should be considered the pioneer volume in having a form of organization like that of *California and the Southwest*. Each chapter covers a different topic for the whole area in the familiar order, beginning with introductory and historical chapters, then physical environment, natural resources, agriculture, industry and commerce, and urban development.

Among the contributors there is a majority of geographers, but other disciplines are well represented, and editorial policy has allowed a wide variety of treatment for a wide variety of topics.

An early chapter suggests a "regional framework" of physiographic divisions and subdivisions, but these are not consistently applicable to many of the topics. In many places the subdivisions used are those of the three and a half states in the area: Washington, Oregon, Idaho, and western Montana, convenient as statistical units at least.

In its subtitle the book is called "An Overall Appreciation" and is not referred to as a regional geography. The Pacific Northwest is introduced as a region having some degree of uniformity and coherence, but this idea is not stressed in the book. The introductory group of chapters, Part I, is headed "Changing Human Adjustments," and ideas of the relations between human life and natural environment are more prominent than any of the regional approaches defined in the regional chapter of *American Geography: Inventory and Prospect*.

The book is a good compilation of topical essays for an important part of the United States. It comes near to being a comprehensive reference book for topics in this area.

[7] Otis W. Freeman and Howard H. Martin, editors, *The Pacific Northwest: An Overall Appreciation* (New York: John Wiley and Sons, 1942). xvi and 540 pp. Maps, illustrations, references, index. 6 x 9. 2nd edition, 1954. $8.50.

Virginia at Mid-Century by Jean Gottmann[8] is very different. It is written by one man, a French geographer, as the product of an original research project. It gives the impression of coming from a mature thinker applying his well-grounded ideas to a new subject, not from a technical expert speaking from previous academic knowledge.

The ideas and viewpoint stem from the classical French regional geography of Demangeon and his followers. But they are not limited to an established mode; they have developed further in the hands of a geographer who has worked on many subjects in America as well as in France. As a matter of fact the ideas seem close to those expressed in *American Geography: Inventory and Prospect*. Indeed, *Virginia at Mid-Century* seems to exemplify the compages of Whittlesey's regional chapter even better than Whittlesey's own exemplification in "Southern Rhodesia."

This is not to say that Gottmann's viewpoint is American. Rather than that it suggests a different and more tenable interpretation: that Whittlesey's ideas were rooted in French regional geography, that both he and Gottmann went on to further development of the same basic concept. A French approach seems apparent in both cases, even though Whittlesey's objective in "Southern Rhodesia" is purely exploratory, to find and describe things as they are, and Gottmann's objective in "Virginia" is in addition remedial, to point out evils for purposes of reform.

As in all the books previously discussed, regional uniformity is a primary concept in "Virginia" also. Within the state as a unit regional variety is recognized: first, eastern Virginia and western; then, within eastern Virginia, two major subdivisions (Tidewater and Piedmont) containing 7 minor subdivisions; within western Virginia 4 major subdivisions (Blue Ridge, Valley, Allegheny, and southwestern triangle) and several less definite minor subdivisions. Each of the subdivisions is described as having some sort of uniformity based on a cluster of criteria, natural and cultural.

Then follow chapters on selected topics in "The Use of Resources," each topic covering all of Virginia but put in relation to the regional subdivisions previously defined wherever fitting.

Historical origins and the products of historical development are emphasized first and last. The view of culture is that of history, not of anthropology. The view of natural environment is that of possibilism, not of determinism. The problems of description are approached with the systematic tools of statistics and cartography and the unsystematic tools of casual observation and inquiry. The problems of explanation are approached with the humanistic tools of rational inference and intuitive judgment. Scientific analysis is less in evidence than artistic synthesis.

The interpretation of Virginia as a unit takes account not only of whatever elements of regional uniformity there are but also of the conscious recognition of regionality in the minds and hearts of Virginians. All this seems consistent with Whittlesey's concept of the compages.

[8] Jean Gottmann, *Virginia at Mid-Century* (New York: Henry Holt and Co., 1955). viii and 584 pp. Maps, illustrations, graphs, index. 6 x 9. $7.50.

So much for these new books in regional geography. Now where do we go from here? Beyond the compages there seems no place to go for the capable competent geographer who is not a genius. The work on a compages calls for the facility of an artist using whatever literary talents and simple geographical devices he may have and not for the method of a scientist with precise, objective analytical tools. The impossibility of going further in such regional geography by scientific method was pointed out effectively by Leighly years ago, when he commented disparagingly on "the vain dream of a science of regions."[9]

Whittlesey, Gottmann, Garland, and others have applied the concept of the compages to an apparently ultimate conclusion. Other talented geographers in the future may make similar applications, and some genius may even produce a compages-masterpiece of an excellence previously unattained and thereafter extolled as a classic. But this can be only as a personal achievement, not made by rules with which other geographers can then produce a flock of compages-masterpieces equal to the prototype or better.

The way to progressively better achievement in regional geography seems not to be through the compages, a dead end in regional method, but along other lines indicated less enthusiastically if at all in the chapter in *American Geography: Inventory and Prospect*.

In addition to the old deceptive definition separating regional from systematic geography there is another prevalent impression which may have become a hindrance in the development of the subject. According to this idea regional geography is concerned fundamentally with places or areas in themselves, an objective areal entity serving as a medium in which other things exist, like the ether of old-fashioned physics, and is not concerned merely with other phenomena spatially related.

Such a concept is properly accompanied by a static form of geography dealing with stationary blocks of area as a mosaic of contrasted uniform bits of space, rather than a dynamic form dealing with the spatial aspects of processes and movements of phenomena in an areal pattern of points and lines.

A clear introductory statement along this line of thought is found in *American Geography: Inventory and Prospect* defining "the region as a device for selecting and studying areal groupings of the complex phenomena found in the earth. . . . So defined a region is not an object, either self-determined or nature-given. It is an intellectual concept, an entity for the purposes of thought, created by the selection of certain features that are relevant to an areal interest or problem and by the disregard of all features that are considered to be irrelevant."

Yet even here the new expression of theory does not erase older forms of thought in the accompanying elaboration of regional types. The nearest approach to a dynamic type is the "nodal region," and even this, as named and defined, is a static substitute for more dynamic forms: a node as a small area of concentration in a large area of dispersion instead of a focal point in a process-pattern of lines and limits of movement.

Abandonment of the idea of areas as objects filled with contents to be dealt with comprehensively carries with it abandonment of the hope to cover the world with a network of regions valid for all purposes and accepted by all geographers, except as an arbitrary filing system for miscellaneous data. Some may regret the failure to discover all-purpose regions embedded in nature as valid objective entities. But the facts of nature have long called for recognition. Now as a matter of fact, after dropping these old illusions, regional geography seems free and ready to go forward as never before, as a method of study equipped with newly sharpened tools of regional analysis and synthesis, including operational field research and cumulative analytical cartography.

The trend is currently represented by Ullman's "analysis of spatial interaction,"[10] Garnsey's "application of abstraction and isolation to regional analysis,"[11] and Philbrick's "nested hierarchy of functions and areas of organization."[12] Perhaps the discarded definition of geography as the science of space might be revived to cover new possibilities: geography as the science of regional process-patterns of dynamic spatial relations.

Regional geography in one form or another seems to be still at the heart of geographic learning. But so is systematic geography. Even compages are somewhat systematic, and other regional studies even more so. For twenty years or more a major trend of development has been along lines of selective systematic regional geography, increasingly concerned with dynamic processes of human occupance in their spatial relations.

ROBERT S. PLATT
University of Chicago

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[9] John Leighly, "Some Comments on Contemporary Geographic Method," *Annals*, Association of American Geographers, Vol. XXVII (1937), pp. 125–141.

[10] Edward L. Ullman, "Human Geography and Area Research," *Annals*, Association of American Geographers, Vol. XLIII (1953), pp. 54–66.

[11] Morris E. Garnsey, "The Dimensions of Regional Science," *Papers and Proceedings of the Regional Science Association*, Vol. II (1956), pp. 27–39.

[12] Allen K. Philbrick, "Principles of Areal Functional Organization in Regional Human Geography," *Economic Geography*, Vol. XXXIII (1957).

THE FACE OF THE EARTH

In 1955 a distinguished group of American and foreign scholars from many disciplines met together at Princeton University in quiet and comfortable surroundings under the auspices of the Wenner-Gren Foundation to exchange information and opinion concerning man's role in changing the face of the earth. What emerged from the exchange is presented in a massive volume, rich in rewarding incongruities of training and tradition, which embodies the background papers and discussions of this Symposium.[1]

The book arrives at no doctrinal position. Its strongest and most moving arguments, eloquently pleaded and almost unanimously seconded, are for an awareness and tolerance of human differences. The Symposium theme itself, of course, implies an assent to the general proposition that man has indeed played a role in changing the earth, but even here one senses that the sympathies of the group are divided—dominant man may be seen both as conqueror and as despoiler of nature.

The discussions, rich in ideas, do not get at the one great idea of Man in Nature. This is not to say that the Symposium fails, for it effectively states the issues and commits itself to the proposition that there is a substantial relation between man and his cultures on the one hand, and the state and processes of the habitat on the other. However, it proposes no fundamentally new ways of seeing mankind in its habitat that might help reconcile our scientific and technological capabilities with human aspirations and values.

The separation of science from philosophy is late and lamentable. We suffer today from a dichotomous approach to the means and ends of action because we have no satisfactory unifying concepts in our science to relate our technological abilities, growing out of science, to the ethical and moral precepts which we have accepted largely as an undivided patrimony from an older time. We yearn for a "scientific" social science, and suppose that by arriving at more efficient mechanistic concepts of society we may achieve manipulation and control, which we mistake for mastery over nature. We sense, nevertheless, that this kind of "progress" puts our liberty in peril. This is the ostensible dilemma of "Brave New World" and "1984" and Zamiatin's "We," but I do not think it is a real dilemma, for we need not be forced to this choice.

The answer does not lie in developing our techniques to manipulate society or somehow to outwit ourselves. The humane and human goal cannot be to protect nature from man, but must be, as it ever has been, to protect man from nature (and technology is only nature brought indoors). We need to know how to achieve our purposes, not how to renounce them.

We are endowed with intelligence; our problem is how to use it. The function of science and of all knowledge would seem ultimately to be the clarification of choices among which intelligence may operate. Intelligent choice is a function of the relation between desired results and anticipated results of action, and our anticipation of results rests upon knowledge. The knowledge we possess is often sufficient in retrospect to explain our mistakes, but we cannot yet use it effectively to foresee the results of our choices.

Our powers are precious only as instruments of our purposes on the physical and living earth. The consequences of our acts should reflect the consequences of our ethical premises and not be left unconsidered until they suddenly rise to astound and dismay us. What we believe in and aspire to, and what we know or can infer, should illuminate our choices so that action serves not merely our cleverness but our greatness. We are starved for moral imperatives; we think only in terms of what can be done, not what should be done. This is a fault of our philosophies.

It has been urged enough that we need a synthesis of all our knowledge, but a synthesis not a compendium; a way to think and not a tabulation. We can have such a synthesis only if we make it a kind of philosophy, a way of measuring and relating things in terms of some common premises to which we commit ourselves.

Man's intervention in the totality of nature has grown so in scope that it is no longer possible to take the natural order as "given" and to preoccupy ourselves exclusively with our changing relations with the supernatural, as was the custom of our forebears. We are too involved in the material world and too much concerned with its metamorphoses to disregard its meanings.

The Princeton Symposium musters ample evidence to show that our acts have consequences here in this world that may be of the greatest moment to us. We know that the mark of man on earth is the product of "the appropriation of habitat by habit," and that this mark—what the geographer calls the "cultural landscape"—is produced by the deflection or modification of physical and biological processes by man. We know further that the intervention of man in these processes, and the effects of that intervention, differ from place to place as human habit differs. We also know a good deal about the natural processes themselves apart from man. What is lacking is a way of bringing all this knowledge into a meaningful order and agreeing on a procedure for making judgments of value based thereon.

Man's intervention in nature can be demonstrated, but it cannot yet be well studied. Man is a mechanical agent, a powerful but portable motor; he moves things. It seems to follow that he might be studied in this aspect, among others, using the scale, terms, and techniques employed in the study of other things with mechanical properties. Above all we might integrate the activity of man and, even more than man himself, machines, into the physical processes we study.

The mechanical capabilities of men and their machines are mostly known, but the manner, rate, and meaning of their interaction with natural processes are only guessed at. We need a wider ecology that will deal with the total function of human action in the habitat as it varies in time, space, and kind.

Man cannot be taken as uniform. His great diversity is manifest in the variety of modified habitats he

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[1] William L. Thomas, Jr., editor, with the collaboration of Carl O. Sauer, Marston Bates, and Lewis Mumford, *Man's Role in Changing the Face of the Earth* (Chicago: University of Chicago Press. 1956). xxxviii and 1,193 pp. 6½ x 9½. Maps, photographs, tables, bibliographies, and index. $12.50.

has made. We know something, but not enough, of human variation. It exhibits certain regularities and inner consistencies which we subsume under our concepts of culture and society and economy and state. The map of the total human habitat is mostly marked off into recognizable units—landscapes that reflect in their physical features the consistent and long-enduring practice of human groups. The surest "regions" are the major and minor units of cultural and societal distribution.

The perception of environment and its possibilities is distinctive in each culture, and each society embodies a distinct mode of relating individual men to one another and to their material environment. The interaction of men with nature is overwhelmingly random and individual; yet, the scope of man's activity is contained within the narrow limits of the known and the permitted, and these are given by culture and society. Although we cannot predict, on the basis of our knowledge of cultures and societies, what a man will do in a given situation, we may well be able to predict what he will *not* do, and this can serve us well.

The universe of human action is thrice bounded—by nature, by knowledge, and by choice. I map it as concentric circles around ourselves. The far limit, scarcely discerned, is remote and absolute, the edge of the physically possible; techniques and custom set another line of human capabilities, which constantly is pushing out to new diameters; and choice, the feasible, contains the region of our action. The diagram is different for each human group, since capabilities and range of choice are varied.

Large decisions firmly held let small decisions guide us. Through their institutions men make large instruments of action move in response to small but critical choices. One of the best developmental measures of societies is the degree to which they specialize their choices and generalize their responses to them. This same measure might serve as index to the ecological potency and self-destructive potential of any society.

Ecology embraces habit. Human behavior is mostly that, and only thus can we study it. The institutions of a society are a key to its ecology, for they are embodiments of human habit and their nature and functions are discoverable. Their operation is more or less regular, orderly, and predictable, and the alternatives that they offer for choice can be known. But we must know also of choice, where it operates, through whom, by what criteria. That is to say, we need an economics of a wider kind.

Economics measures variations in the operation of institutions, which are the expression of small decisions within them. Such variations in institutional function occur in all societies as a result of small decisions. The net effect of many such choices on the operation of an institution—and on the ecological relations of a society—may be very great.

For most societies we need to know more of the institutional pattern before we can talk about choices within it. We are ignorant as to the distribution and function of systems around the world, and we have yet no common denominators that might allow us to compare and analyze them in their spatial and ecological expressions. We understand too little of our dimensions as an ecologic factor. We sense that time has shrunk and space expanded for the Western World, and choice is spread and specialized while ever-greater powers concentrate to do its bidding. The small decisions that our acts obey are made in ignorance of great effects.

We split the economic atom long ago. The nuclear bond that held us close to habitat has yielded; the particles of human energy and skill are freed for "jobs." The discovery that we can apply human labor where and how we please to limited tasks, minutely organized, has made more difference than atoms ever will. We discovered "positive and negative charges" on human behavior—production and consumption—and we learned to separate them. We have infinitely more kinds of fundamental particles in man than in the atom nucleus—productive skills—and they are manageable.

Producer-consumer, household and firm, once were one. This was the natural state, and man reaped as he sowed, dependent on nature and watchful of all her moods. Now we are dual. We think of consuming in terms of itself, and choices are made as if the only factors to be considered were those of the living standard and the household budget. We think of production in terms of response to demand from consumers. Responsibility is placed on the consumer to make the decisions that regulate action. But consumers tend to think only of themselves and their small microcosms.

Small decisions add up. The total effect of consumer decisions, magnified by the generalized response of our whole technology, is tremendous. But each decision itself is minute, and the feeling of responsibility for vast consequences is lacking. Our alteration of nature to its detriment can have great effect, but this effect will be measured out to the multitude of consumers again in small doses. Their indifference is well-founded. Catastrophic events will reach most of them only as minor annoyances and minute deprivations.

What can preserve us? In our society we have to rely on the soundness, the ecological wisdom, of small decisions, the small decisions of consumers. These are the ecologically illiterate and heedless, and in fact they are all of us, the informed with the rest. Sufficient knowledge of the full consequences of each small act cannot be brought to bear on the occasion of each decision; it is out of scale. We use our knowledge to arrive at general premises from which certain conclusions follow, and if we are wise, we try to act in accordance with those conclusions. This is the substance of morality.

Where reason may fail us, our morals protect us. Morality insists that we make all of our choices, even the smallest, as though each were the greatest and last and held in it our destiny. It informs us how to behave consistently with what we believe to be true.

The truth that morality serves is ours to propose. It need not respond to a supernatural order nor to an absolute metaphysic. We need a morality that will instruct us to act wisely as natural beings, a guidance in our small decisions that reflects our greater understandings. If we have not this way of making choices intelligently, we have none in our kind of society.

I have reflected on the contents of this volume, reporting and interpreting ideas, and here and there suggesting further lines of thought. Now let me write of the book itself and how to use it.

If I wished to read *Man's Role in Changing the Face of the Earth* with fullest benefit, I should approach it neither as an encyclopedia nor as a serial story. It is selective rather than exhaustive in topical coverage, and the articles are not always statements of expert consensus (*e.g.*, in Old World prehistory or the prognosis for mineral fields), and so it cannot be a real encyclopedia. On the other hand, to read it serially is to lose the thread of thought within it.

I think perspective is best gained by reading first Carl Sauer on "The Agency of Man on Earth," and then Paul Sears's "The Process of Environmental Change by Man." I recommend that Northrop's paper, "Man's Relation to the Earth in its Bearing on his Aesthetic, Ethical, and Legal Values," follow these, and then the summary remarks of Lewis Mumford on "Prospect." All of these are full of major insights, and they orient the whole discussion. Sauer, Marston Bates, and Mumford were co-chairmen of the Symposium, presiding over sessions which are called respectively "Retrospect," "Process," and "Prospect," terms by which their several ways of thought are well expressed. F. S. C. Northrop, a philosopher, relates the whole debate to wider questions.

Next I should read the discussions. They are real exploration, free and creative. The reader will choose his favorite passages. I like parts where Frank Knight and his fellow economist Kenneth Boulding, the biologists Fraser Darling, Edgar Anderson, and Marston Bates, the anthropologist Sol Tax, and the geographer Pierre Gourou speak. They speak wisely, and say something new.

There are fifty-two background papers. Some will be classics. I would read them at first with questions in mind in the context of thought the discussions create, and later return to reread them. Many of the articles are condensed statements of views and information that their authors have presented more fully elsewhere, but some are unique in their data and argument. We are likely to come back to this book more than once for the critical reasoning of Sir Charles Darwin's "The Time Scale in Human Affairs"; the original ideas and observations in Edgar Anderson's "Man as a Maker of New Plants and New Animal Communities"; the elegance of concept of Arthur Strahler's "The Nature of Induced Erosion"; the well-documented synthesis of H. H. Bartlett's "Fire, Primitive Agriculture, and Grazing in the Tropics"; the conceptual usefulness of Edward Ullman's "The Role of Transportation and the Bases for Interaction"; the definitive scholarship of H. C. Darby's "The Clearing of the Woodland in Europe"; the inspiration of Pierre Teilhard de Chardin's "The Antiquity and World Expansion of Human Culture"; and for other stimulating and valuable things it contains. The Symposium volume will be a useful reference, a rewarding book to browse in, and an incentive to further research and reflection for a long time to come.

PHILIP L. WAGNER
The University of Chicago

SOME RECENT LITERATURE ON PORTS

The recent appearance of two books dealing with specialized aspects of ports marks the continuation of a trend in recent years toward port analysis from an increasing number of viewpoints.[1] World ports in the mid-twentieth century have evolved into inordinately complex affairs, although most of the elements associated with modern ports were present in the preceding century when the modern port first took shape. Neither the traditional, technical descriptions of port facilities, nor the general descriptions of ports as a whole, which collectively constituted most of the literature on ports until the end of the 1930's, provided by themselves a reasonable full coverage of structure and function of the modern port. Each of these rather slender volumes, therefore, enhances our perspective on the nature of ports.

The two volumes understandably differ markedly in viewpoint and treatment. Dr. Thoman, a geographer, discusses the free ports of northwest Europe and the foreign trade zones of the United States from a geographic point of view in an attempt to measure and analyze the level of success achieved by the free port or foreign trade zone device at various ports. Dr. Fair, an economist and transportation specialist, makes a heroic and fairly successful attempt to penetrate the morass of variation in port administration. The problems and operational consequences of the administrative structures of port bodies in the United States are analyzed. In Thoman's work, ports are treated in the context of diversified earth-space and resulting traffic flows; in Fair's work, attention is fixed steadfastly on systematic aspects of port authority in a book which may properly be regarded as being in the fields of political science and political economy.

Thoman concentrates much of his attention on the free ports of northwest Europe, where out-of-customs zones are confined to certain German and Scandinavian ports. Whereas in Scandinavia the free-port districts of Stockholm, Malmö, Göteborg, and Copenhagen were set up for purely economic reasons during the current century, the German free-port districts of Hamburg and the Bremen-Bremerhaven complex are associated additionally with a certain surviving free-city traditionalism stemming from pre-Bismark economic unification. Thoman concludes that even where the free port includes a large portion of the total port and handles a large volume of traffic, as in Hamburg, the free port does not function primarily in terms of its ostensible purpose; most incoming traffic by sea is not re-exported, but rather is imported eventually into the host country. Moreover, much of the attraction for the device seems to stem actually from the existence of excellent waterfront facilities in some of the customs

[1] Richard S. Thoman, *Free Ports and Foreign Trade Zones* (Cambridge, Md.: Cornell Maritime Press. 1956). xii and 203 pp. Maps, diagrams, illustrations, bibliography, index. 6 x 9. $7.00.

Marvin L. Fair, *Port Administration in the United States* (Cambridge, Md.: Cornell Maritime Press. 1956). xvi and 217 pp. Diagrams, illustrations, appendices, index. 6 x 9. $6.00.

exclaves. None of the five American free-trade zones, the counterpart of the European free ports, have been outstandingly successful, and again, as in Europe, reexport is unimportant.

Thoman's successive study of various free ports leads him frequently to similar conclusions, and since summarizing conclusions are also included, some inevitable repetition results. Brief discussion is undertaken of Rotterdam, Antwerp, and London, where bonded warehousing and other alternatives to free ports are used. This section, useful and interesting, might well have been expanded to include more comparative analysis of a traditional entrepôt, such as London, with the free ports of Germany and Scandinavia.

Fair is perhaps most enlightening when he summarizes the organizations, functions, and trends of port authorities in the United States. He suggests that most ports were administered by government departmental agencies until the present century, but now the independent port commission and, even more, the public corporation, compose the most widespread media through which ports are administered. The trend toward the greater use of the public corporation, a legal entity, unlike the port commission, is related to its greater flexibility in action in the development and administration of today's increasingly complex port areas. Much of the book is not easy to read; basically it may more properly be construed as a reference volume for the minutiae of port administration. Yet, it deserves recognition as a competent first book on the general field of port administration in the United States. Geographers may be guided accordingly, depending on the degree of their specialized interest in ports.

In the United States in recent years a growing perceptiveness of the economic ramifications of port activity is arousing a greater interest in the competitive economic status of ports and in port development programs. Concurrently, attitudes toward the modern American port have gradually been changing. Fair has sketched the evolution over the past century of the public concept of a port from that of a public way or route (nineteenth century) to that of a public utility, with the recent gradual emergence of a third concept, that of the port as a public utility business enterprise. Now it would seem that these subtle changes in thinking relative to ports are both a result of the modern structural evolution of the port and a cause of administrative changes in port areas. These changes in turn have paralleled and encouraged the broadening basis from which ports have been treated in the rapidly growing volume of American port literature.

Profound stirrings, both physical and psychological, have touched American port areas since the end of World War II. Much of the furor raised in postwar development programs has been created by talk and blueprints, but at least realization has been achieved of the competitive need for sustained progress in the streamlining of cargo handling, and initiation of action has been widespread. Many ports are manfully struggling to rid themselves of areas of antiquated waterfront facilities, constructed in the day when all goods not arriving at or leaving the dock by rail car moved by horse and wagon. Growing interest has centered on the contributions which ports make to the cities associated with them, and to the general regional economy of larger areas which they serve. Also the secular trend toward the consolidation of American import and export trade in fewer and fewer ports has gradually been halted and then reversed, presenting opportunities for new ports and competitive problems for ports endeavoring to retain their positions. State and local governmental units have increasingly pushed port development in order to divert supposed economic benefits in their direction, and this trend has been augmented by the construction of new industries with import and export needs at many points along American coastlands. The prospects for increased importation, highlighted in the Paley Report and dramatized by the sudden scramble for overseas iron ore, have buoyed up sanguine predictions of future port activity. Negative stimuli, including fear of loss of trade once the St. Lawrence Seaway is completed, have been present too. Other far-reaching factors with implication for port developments are the establishment of export departments in more American industries seeking to enlarge foreign market channels on a large scale, and the expansion in postwar cargo liner routes and services looking for regular trade opportunities at an increasing number of American ports.

The heightened sense of port rivalries and port potentialities and an increased feeling for the urgency of "selling the port" are, of course, reflected in a growing volume of purely promotional literature published by port authorities and trade associations. Port promotion is indirectly stimulating the writing of unpublished reports for various port groups, associations, and authorities. Typical are the increasing number of detailed "trouble-shooting" technical and traffic studies made for port bodies by engineering consulting firms. Designed to focus attention on remedial programs for both short- and long-range action, they quite frequently provide detailed, penetrating data on aspects of a port's physical equipment. When such reports encompass traffic studies, however, the results are usually far less happy; findings are overgeneralized and often erroneous. Meanwhile, the pages of the port and shipping periodicals are more crowded than ever with "recent development" articles relative to various ports. Sandwiched in among articles of rampant bias are reports of refreshing detachment and scholarship. Probably of most use to the geographer are scattered articles in *World Ports* and *Marine News*.

In a different category are an increasing number of monographs, produced most frequently at educational institutions of seaboard states in which scholarly treatment is given to problems confronting the local ports. Examples are (1) John L. Hazard, *Crisis in Coastal Shipping*, Bureau of Business Research, University of Texas, Research Monograph No. 16, 1955, and (2) Henry A. Peck, *Seaports in Maine; An Economic Study*, University of Maine Studies, Second Series, No. 70, 1955. Even in such studies, however, sympathy for local port problems may creep in; to wit, the amazing recommendation in Peck's monograph that port differentials for rail export traffic should be equalized for all North Atlantic ports, thus giving Maine ports a better competitive chance to handle some of this export traffic, and that ocean freight rates to the same Atlantic ports should be de-equalized, in order that due recognition be given shorter transatlantic distances

to and from Maine ports! The quickening interest in the economic relations of port functions to port cities and states is illustrated by (1) *The Economic Importance of Port-Linked Manufacturing Industries in the Baltimore Metropolitan Area*, Maryland State Planning Commission, 1953, and (2) *The Impact of Virginia Ports on the Economy of Virginia*, University of Virginia, Bureau of Population and Economic Research, 1954.

Again of a different nature are the studies of the port of New York's foreign trade routes, prepared by the Port Development Department of the Port of New York Authority. The Authority has been engaged in the most detailed statistical analyses to date of foreign trade routes out of an American port. Meanwhile the latest editions of the *Port Series*, prepared jointly by the U.S. Board of Engineers for Rivers and Harbors, and the U.S. Maritime Administration, promise to provide a continued excellent but purely factual reporting on port physical facilities and commercial organizations, and on the supporting transport and storage facilities back of the waterfront.

A large volume of specialized port material is being prepared in association with the forthcoming port differential hearings, in which the more northerly of the North Atlantic ports, with some of the northern trunk line railroads as allies, will make another attempt to eliminate the port differentials enjoyed by Philadelphia, Baltimore, and the Hampton Roads ports. Judging from unpublished but available briefs and exhibits presented before the Interstate Commerce Commission in connection with recent hearings on coal, grain, and iron ore differentials, a sizeable volume of raw material soon may become available, which may provide some interesting insights into current traffic relationships with the several North Atlantic ports.

DONALD PATTON
University of Maryland